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NAS WHITING FIELD
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FINAL REMEDIAL INVESTIGATION FEASIBILITY STUDY PLANNING DOCUMENT WORK PLAN VOLUME 2 OF 3 NAS WHITING FIELD FL

6/1/1990

E C JORDAN ENGINEERS

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REMEDIAL INVESTIGATION/FEASIBILITY STUDY PLANNING DOCUMENT

NAVAL AIR STATION WHITING FIELD

MILTON, FLORIDA

UIC: N60508

VOLUME II

SAMPLING AND ANALYSIS PLAN

JUNE 1990

Contract N62467-88-C-0382

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1.0 INTRODUCTION

E.C. Jordan Co. (Jordan), under contract to Southern Division, Naval Facilities Engineering Command, has prepared this Sampling and Analysis Plan (SAP) for a Remedial Investigation/Feasibility Study (RI/FS) at the Naval Air Station (NAS) Whiting Field, Milton, Florida. This SAP contains the field procedural information required to complete the tasks described in the NAS Whiting Field Work Plan (Volume I).

The purpose of the SAP is to ensure that sampling of environmental medium and other data collection activities will be comparable to and compatible with previous data collection activities. It also provides the mechanism for planning and approving field activities. In that this SAP is a dynamic document it will be amended or revised, on an as-needed basis, during the Remedial Investigation (RI) site characterization, treatability investigation, or during the Feasibility Study (FS) as the requirement for field activities is reassessed or rescoped.

The NAS Whiting Field Work Plan (Volume I) contains the rationale and overall approach for the proposed RI/FS activities. It also provides additional background information and includes a review of the existing database for the sites. The Work Plan discusses the scoping process for the RI/FS, including a preliminary risk assessment, the identification of remedial alternatives and the identification of RI/FS objectives (including Applicable or Relevant and Appropriate Requirements [ARARs] and Data Quality Objectives [DQOs]). The RI, described in the Work Plan and detailed in this SAP, includes the following activities: piezocone penetrometer tests, *in-situ* groundwater sampling, surface and subsurface soil sampling, monitoring well installation, surface water and sediment sampling, chemical laboratory analyses, and monitoring well measuring point survey. Each RI activity will be conducted in accordance with U.S. Navy and U.S. Environmental Protection Agency (USEPA) guidelines, this SAP, and the site-specific Health and Safety Plan (HASP). Changes in the established guidelines and protocols made because of field circumstances will be recorded and documented. Procedures and documentation for field changes and corrective action are presented in Section 3.1.11 of this SAP.

The SAP is divided into three major parts: the Site Management Plan (SMP) (Section 2.0), the Field Sampling Plan (FSP) (Section 3.0), and the field investigation Quality Assurance Program Plan (QAPP) (Appendix B). These plans include the following types of information.

- The SMP includes the operations plan outlining the field team organization and responsibilities to the project. The SMP also addresses site security and control of access by unauthorized personnel.

- The FSP includes sampling and analytical objectives and the number, type, and location of samples to be collected during the field investigation.

- The QAPP includes standard operating procedures and the quality assurance/quality control (QA/QC) objectives and procedures for field activities.

The specific Laboratory Analysis Quality Assurance Plan shall be submitted at the time of the subcontract award for laboratory services. The analytic laboratory selected for this project shall be approved under the Navy's Installation Restoration (IR) Program.

<u>1.1 SITE LOCATIONS AND DESCRIPTIONS.</u> NAS Whiting Field is located in Florida's northwest coastal area approximately 7 miles north of Milton and 20 miles northeast of Pensacola (Figure 1-1). It is divided into two fields. The North Field is used for fixed-wing training and the South Field is used for helicopter training (Figure 1-2). NAS Whiting Field provides support services and facilities for flight and academic training.

Since its commission in 1943, NAS Whiting Field has generated a variety of wastes related to pilot training, the operation and maintenance of aircraft along with ground support equipment, and the station's facility maintenance activities. Both liquid and solid wastes from these sources have been disposed of at various places on the base. Most of the waste disposal operations and activities at the station are now provided by private contractors.

An Initial Assessment Study (IAS) (Envirodyne Engineers, 1985) identified 16 past waste-disposal sites at NAS Whiting Field (Table 1-1). Based on this study, 15 sites were recommended for further evaluation. Site 2 (Northwest Open Disposal Area) was judged not to warrant further consideration. In November 1985, Geraghty & Miller, Inc. prepared a Work Plan for the Navy for a Verification Study which was subsequently submitted to the Florida Department of Environmental Regulation (FDER). After discussions with the FDER on 17 December 1985, changes to the Work Plan were made and two additional sites (17 and 18) were added (see Table 1-1). Both of these crash crew training areas are active sites where waste oils and fuels are burned during fire fighting training exercises. A summary of activities at each site is presented in Table 1-2.

Of the 18 sites identified to date, 13 are scheduled for further study under the Navy's IR Program. Site 5, the Battery Acid Seepage Pit, was extensively studied in 1985 (Geraghty & Miller, 1985) in response to a Florida Department of Environmental Regulation (FDER) entered Consent Order (84-0253). Results indicated no significant contamination resulting from past activities at the Battery Acid Shop and the Consent Order was recommended to be recended on 15 April 1987. However, the presence of benzene in the existing monitoring wells surrounding the seepage pit does warrant further consideration. As such, the investigation of benzene contamination around Site 5 will be coupled with the field and laboratory investigation proposed for production well W-S2. Sites 4, 7, and 8 are slated for investigation and remediation, if necessary, under the Navy's Underground Storage Tank (UST) Program and, therefore, are not incorporated in the Navy's IR Program.

The locations of the 18 sites identified under the IR Program are shown on Figure 1-3 (Appendix A). A brief discussion of the sites scheduled to undergo a Phase I Remedial Investigation is presented in the following sections. A more detailed description of the sites is provided in the NAS Whiting Field Work Plan (Volume I of this document).

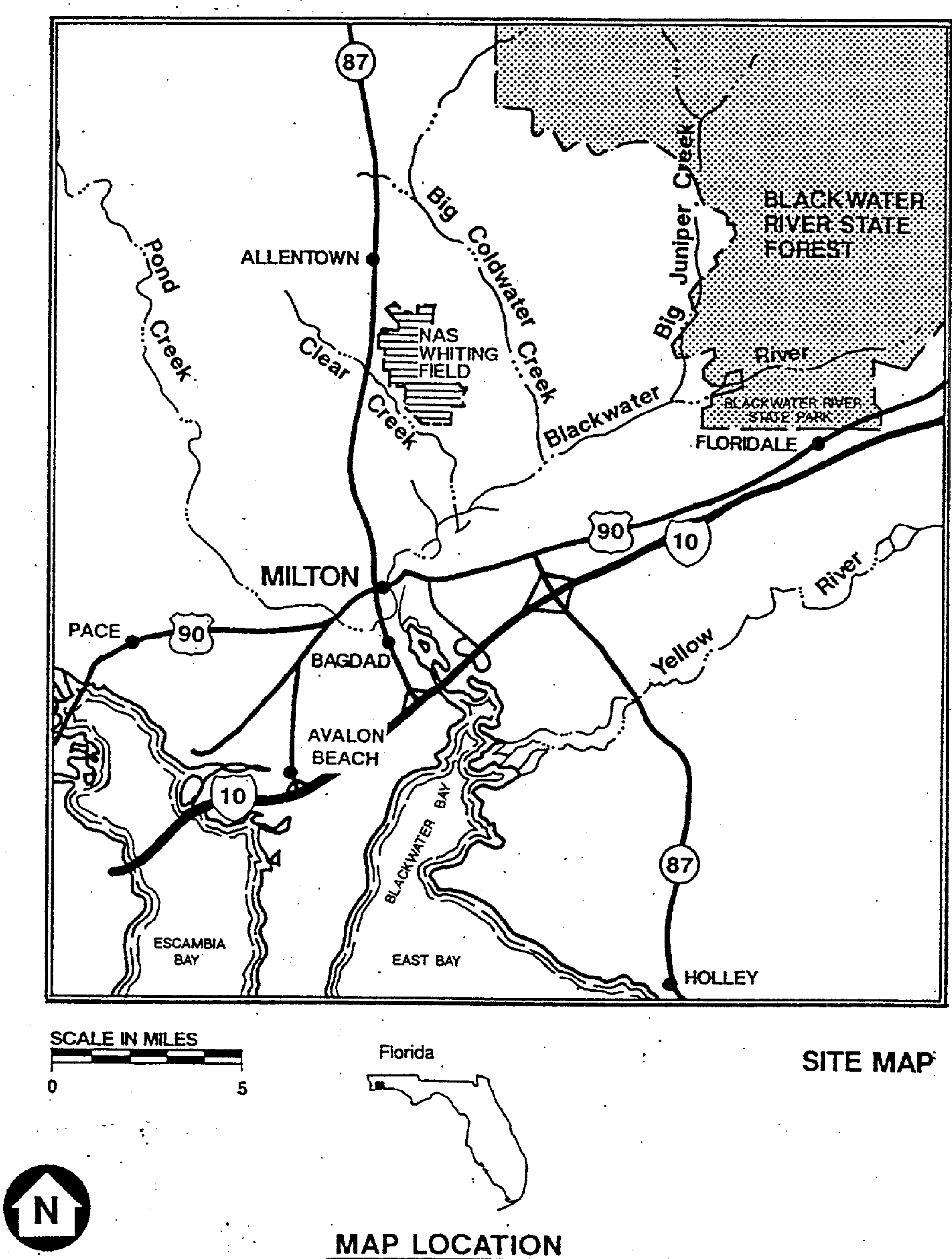
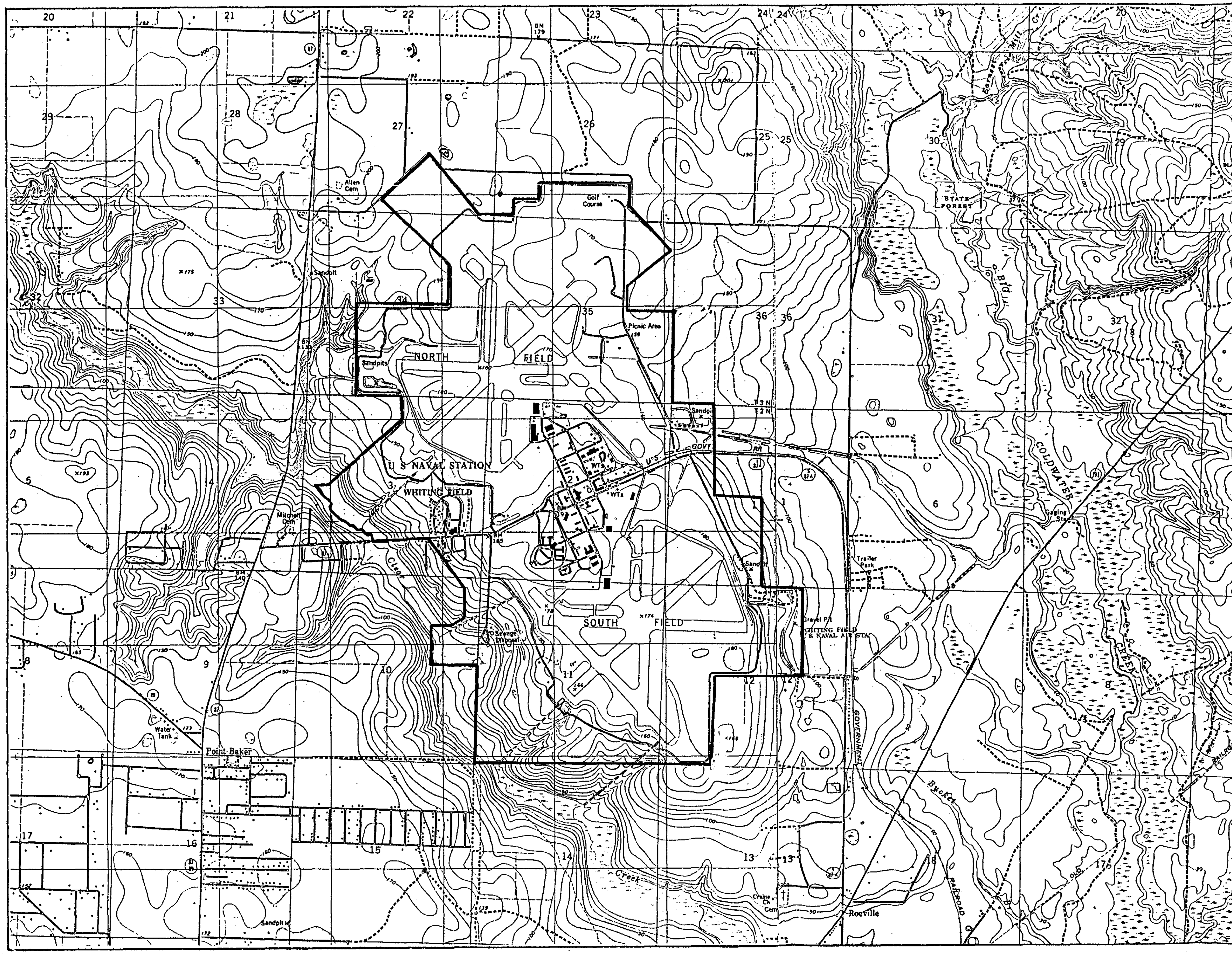


FIGURE 1-1

FACILITY LOCATION MAP

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA



SCALE IN FEET

0 3000 6000

SOURCE:
USGS QUADRANGLE MILTON NORTH, FLORIDA
PHOTOREVISED 1987
AND USGS QUADRANGLE HAROLD, FLORIDA 1973.

FIGURE 1-2

NAS WHITING FIELD

**RI/FS WORK PLAN
SAMPLING AND ANALYSIS
NAS WHITING FIELD
MILTON, FLORIDA**

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TABLE 1-1
SUMMARY OF SITE INVESTIGATION
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

SITE NUMBER	SITE NAME	IAS	VERIFICATION STUDY	CONSENT ORDER	RI/FS	NAVY'S UST PROGRAM
1	Northwest Disposal Area	*	*		*	
2	Northwest Open Disposal Area	*				
3	Underground Waste Solvent Storage Area	*	*		*	
4	North AVGAS Tank Sludge Disposal Area	*	*			*
5	Battery Acid Seepage Pit	*		*		
6	South Transformer Oil Disposal Area	*	*		*	
7	South AVGAS Tank Sludge Disposal Area	*	*			*
8	AVGAS Fuel Spill Area	*	*			*
9	Waste Fuel Disposal Pit	*	*		*	
10	Southeast Open Disposal Area (A)	*	*		*	
11	Southeast Open Disposal Area (B)	*	*		*	
12	Tetraethyl Lead Disposal Area	*	*		*	
13	Sanitary Landfill	*	*		*	
14	Short-Term Sanitary Landfill	*	*		*	
15	Southwest Landfill	*	*		*	
16	Open Disposal and Burn Area	*	*		*	
17	Crash Crew Training Area		*		*	
18	Crash Crew Training Area		*		*	

NOTE: IAS - Initial Assessment Study
RI/FS - Remedial Investigaiton/Feasibility Study
UST - Underground Storage Tank

TABLE 1-2
SUMMARY OF DISPOSAL SITE ACTIVITIES
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

SITE NO.	SITE NAME	LOCATION	PERIOD OF OPERATION	TYPES OF MATERIAL DISPOSED	COMMENTS
1	Northwest Disposal Area	North Field, west side	1943-1965	Refuse, waste paints, thinners, solvents, waste oils, hydraulic fluids	Secondary disposal area during this period; site covers 5 acres.
2	Northwest Open Disposal Area	North Field, west side	1976-1984	Construction and demolition debris, tires, furniture	Former borrow pit location, commonly referred to as the "Wood Dump".
3	Underground Waste Solvent Storage Area	North Field, south of Building 2941	1980-1984	Waste solvents, paint stripping residue	Wastes generated by paint stripping operations.
4	North AVGAS Tank Sludge Disposal Area	North Field, north of Tow Lane	1943-1968	Tank bottom sludge containing tetraethyl lead	Sludge disposal in shallow holes near tanks.
5	Battery Acid Seepage Pit	South Field, Near Building 1478	1964-1984	Waste electrolyte solution containing heavy metals	Pits located 110 feet from potable supply well (W-S2).
6	South Transformer Oil Disposal Area	South Field, Building 1478	1940's-1964	PCB-contaminated dielectric fluid	Disposal in "0-2" drainage ditch.
7	South AVGAS Tank Sludge Disposal Area	South Field, West of Building 1406	1943-1968	Tank bottom sludge containing tetraethyl lead	Sludge disposed in shallow holes near tanks.
8	AVGAS Fuel Spill Area	South Field, South of Building 1406	Summer 1972	AVGAS containing tetraethyl lead	Fuel spill of about 25,000 gallons on an area of about 2 acres.
9	Waste Fuel Disposal Pit	South Field, east side	1950's-1960's	Waste AVGAS containing tetraethyl lead	Fuel disposed in former clay borrow pit.

TABLE 1-2 (Cont.d)
SUMMARY OF DISPOSAL SITE ACTIVITIES
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

SITE NO.	SITE NAME	LOCATION	PERIOD OF OPERATION	TYPES OF MATERIAL DISPOSED	COMMENTS
10	Southeast Open Disposal Area (A)	South Field, southeast area	1965-1973	Construction and demolition debris, waste solvents, paint, oils, hydraulic fluid, PCBs, pesticides, herbicides	Secondary disposal area during this period; site covers about 4 acres.
11	Southeast Open Disposal Area (B)	South Field, southeast area	1943-1970	Construction and demolition debris, waste solvents, paint, oils, hydraulic fluid, PCBs	Secondary disposal area during this period; site covers about 3 acres.
12	Tetraethyl Lead Disposal Area	South Field, southeast area	May 1, 1968	Tank bottom sludge and fuel filters contaminated with tetraethyl lead	Disposal area posted with warning; site consists of two earth covered mounds, 25 ft. x 25 ft. area.
13	Sanitary Landfill	South Field, southeast area	1979-1988	Refuse, waste solvent, paint, hydraulic fluids	Primary sanitary landfill, potentially received hazardous wastes the first year of operation.
14	Short-Term Sanitary Landfill	South Field, southeast area	1978-1979	Refuse, waste solvent, oils, paint, hydraulic fluids	Primary sanitary landfill for brief period; relocated due to drainage problems.
15	Southwest Landfill	South Field, southwest area	1965-1979	Refuse, waste paint, oils, solvents, thinners, asbestos, hydraulic fluid	Primary landfill for this time period; covers about 15 acres.
16	Open Disposal and Burning Area	South Field, southwest area	1943-1965	Refuse, waste paint, oils, solvents, thinners, PCBs, hydraulic fluid	Primary disposal area for this time period; covers about 10 acres.
17,18	Crash Crew Training Areas	North Field, east side	1951-Present	JP-4	Waste fuels and some solvents ignited, then extinguished.

1.1.1 Site 1 - Northwest Disposal Area Site 1 covers an area of approximately 5 acres and is located just west of the perimeter patrol road and north of the "E" drainage ditch (see Figure 1-3, Appendix A). This site was used as a general refuse disposal area from the time NAS Whiting Field was established in 1943 until around 1965. The site is in a depression which is approximately 10 feet below the perimeter road. The site plan of Site 1 is shown on Figure 1-4.

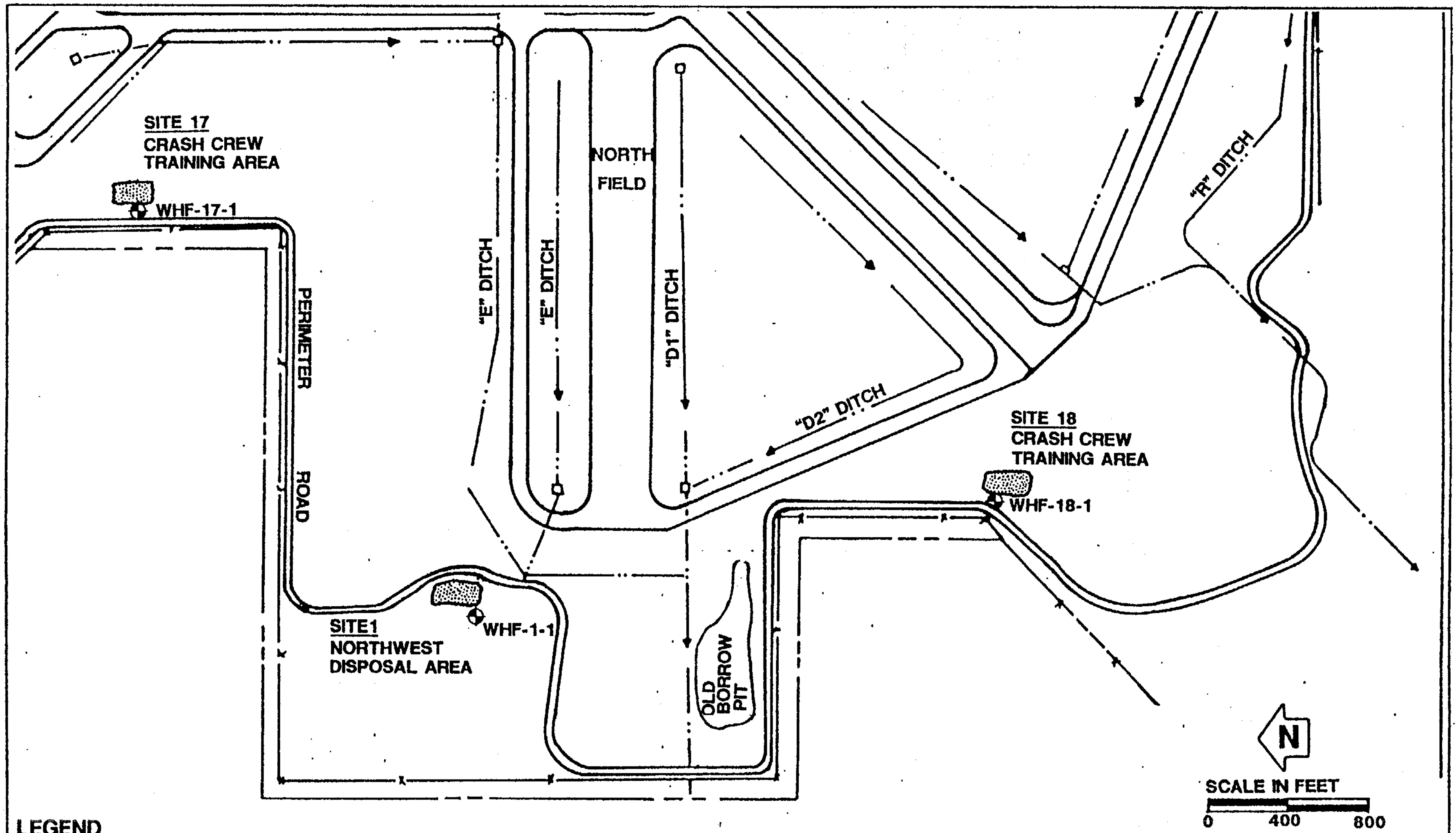
Wastes disposed at this site primarily included general refuse and wastes associated with the operation and maintenance of aircraft (paint, paint thinner, solvents, waste oils, and hydraulic fluid). Access to the site was uncontrolled and there are no records on the types of wastes disposed at Site 1. Table 1-3 summarizes the types and quantities of wastes potentially disposed at Site 1.

1.1.2 Site 3 - Underground Waste Solvent Storage Area Site 3 is located approximately 90 feet south of Building 2941 and just north of Paint Locker, structure 2987 (see Figure 1-3, Appendix A). Two 550-gallon underground metal tanks were used from 1980 to April of 1984 for the storage of waste solvents and residue generated from paint-stripping operations conducted at Building 2941. Wastes from the tanks were periodically pumped out for disposal off Navy property. The site plan for the Underground Waste Solvent Storage Area is shown on Figure 1-5.

In April of 1984, use of the underground tanks was discontinued and the two tanks were removed from the site. During excavation operations at the site, one of the tanks was punctured by a backhoe, resulting in the spillage of approximately 120 gallons of waste solvents onto the ground. Clean-up operations conducted at the site resulted in the recovery of approximately 50 gallons of the waste solvent. In addition, approximately 6 cubic yards of contaminated soil were removed from the site and taken off Navy property for disposal. Examination of the tanks after their removal revealed holes up to 0.5 inch in diameter. The holes were apparently caused by the waste solvents corroding through the metal tanks. The extent to which the paint-stripping wastes leaked from the tanks is unknown. A sample of sludge material that had accumulated in the tanks was collected for chemical analysis during the tank excavation operations. Table 1-4 summarizes the analytical results for this sample.

In addition, an underground storage tank, used for waste oil storage, existed to the northwest of monitoring well WHF-3-1 (see Figure 1-5). Geraghty & Miller (1986) report that the tank was used for the storage of waste oils, spent hydraulic fluids, and possibly some waste solvents. This tank was removed in January 1986.

1.1.3 Site 6 - South Transformer Oil Disposal Area The location for the disposal of transformer oil was the "O-2" drainage ditch (Figure 1-6, Appendix A), which is about 700 feet from production well W-S2 and about 500 feet southeast of Building 1454. From the 1940's until 1964, Building 1478 (currently the battery shop) was used as a transformer repair and rework shop. Prior to servicing the transformers, the dielectric fluid, which potentially contained polychlorinated biphenyls (PCBs), was reportedly drained into the grassed "O-2" drainage ditch. Disposal operations were discontinued in 1964 when Building 1478 was converted into the battery shop. This ditch has since been paved.



LEGEND

WHF-1-1 EXISTING MONITORING WELL

FIGURE 1-4

SITE PLAN
SITES 1, 17, & 18

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

TABLE 1-3
WASTES POTENTIALLY DISPOSED AT SITE 1, NORTHWEST DISPOSAL AREA
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

WASTE	SOURCE OF WASTE	TIME PERIOD	ESTIMATED* TOTAL QUANTITY	COMMENTS
General refuse	Naval Air Station	1943 to 1965	--	Site 1 was a secondary disposal area during this period (Site 16 was the primary).
Paint stripping wastewater	AIMD Paint Shop	1943 to 1965	200,000 gallons	Paint stripping wastes diluted significantly with copious amounts of rinse water.
Waste paints and thinners	Operations Maintenance Division	1943 to 1960	300 gallons	**After 1960, this waste went to the Fire Fighting Training Area.
Solvents (MEK, toluene, xylene, and PD-680)	Air Frame Shop, Aircraft Maintenance, Transportation Division Shop	1943 to 1965	20,000 gallons	**
Waste oils and hydraulic fluids	Operations Maintenance Division, Transportation Division Shop	1943 to 1965	40,000 gallons	**

Note: * - Assumes 3/10 of the total maximum yearly waste generated was disposed at Site 1, 1/5 disposed at Site 11, and 1/2 disposed at Site 16; estimates rounded to one significant figure.

** - Maximum quantity disposed at this site and Fire Fighting Training Area

Source: Envirodyne Engineers (1985)

TABLE 1-4
CHEMICAL ANALYSIS OF WATER FROM THE PAINT
STRIPPING RINSE TANK AT BUILDING 2941
(MAY 1981)
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

PARAMETER	ANALYSIS
Ignitability:	Non-flammable
Corrosivity:	pH 7.40, not corrosive based on pH corrosivity characteristic
Reactivity:	Non-reactive
Total Phenols, mg/l	1866
Total Suspended Solids, mg/l	184
Total Organic Carbon, mg/l	2140
EP Toxicity:	
Arsenic, mg/l	< 0.001
Barium, mg/l	0.20
Cadmium, mg/l	0.10
Chromium, mg/l	36.2
Lead, mg/l	0.093
Mercury, mg/l	< 0.0004
Selenium, mg/l	< 0.0007

Source: Geraghty & Miller (1986)

NOTE: mg/l - milligrams per liter

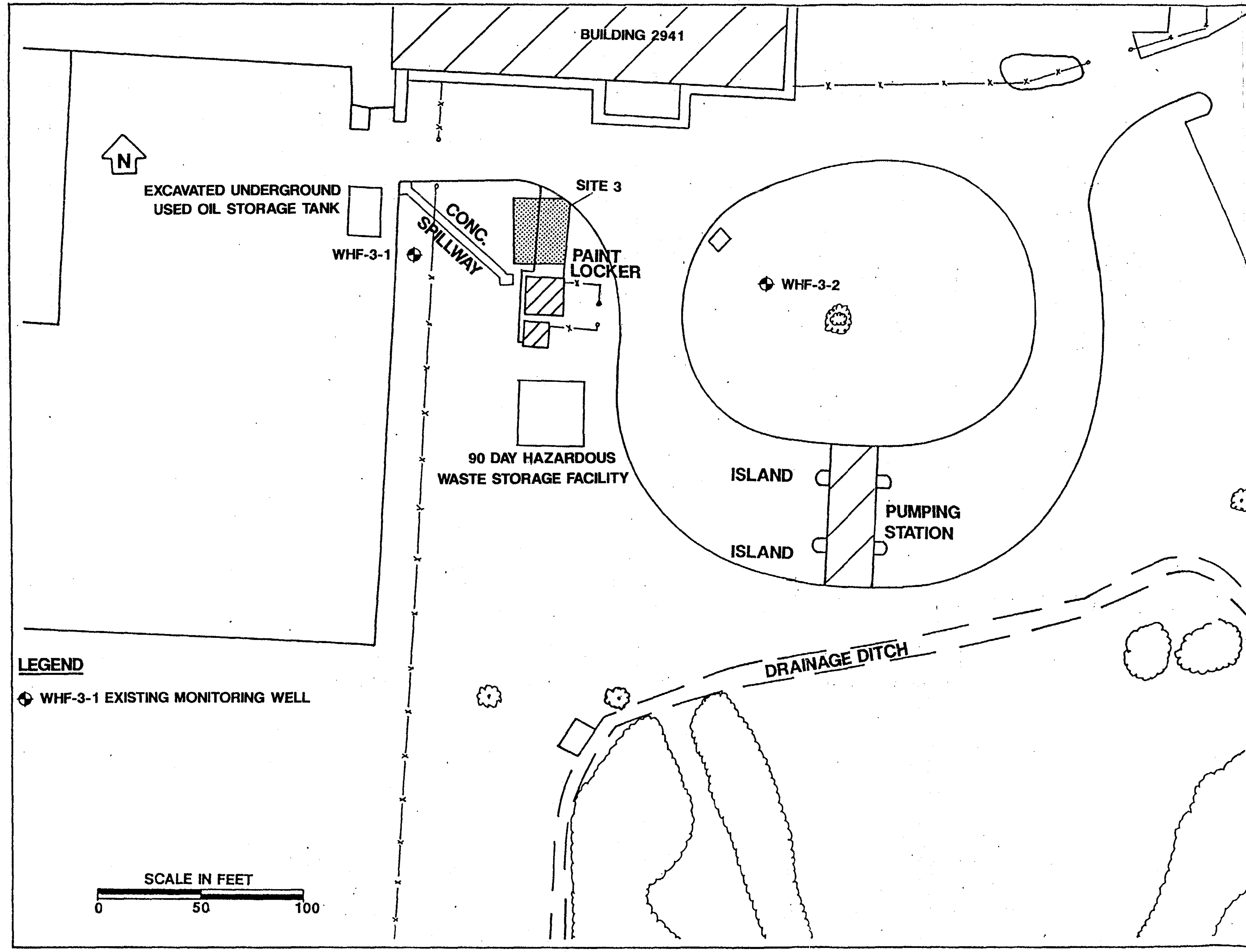


FIGURE 1-5

SITE PLAN
SITE 3 - UNDERGROUND
WASTE SOLVENT STORAGE AREA

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

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1.1.4 Site 9 - Waste Fuel Disposal Pit Site 9 is located along the eastern property line near South Field (see Figure 1-3, Appendix A). During the 1950's and 1960's, waste fuel was disposed in a clay borrow pit. The waste fuel disposal pit reportedly has been covered over. The precise location of the disposal pit is unknown. However, the pit was reportedly located in the northern portion of an existing borrow pit, as shown in Figure 1-7. During the 1950's and 1960's, tank trucks transported waste fuel, which contained tetraethyl lead, for disposal in the northern portion of the borrow pit. Approximately 200 to 300 gallons of waste fuel were disposed at the site per trip. The total quantity of waste fuel disposed at the site during this period of time, however, is unknown.

The Envirodyne Engineers (1985) IAS reported that the general area where the disposal pit is located can be characterized as a depressed area approximately 10 feet below the grade of the perimeter road. Surface runoff from Site 9 and portions of Site 10 is towards this depression where it apparently ponds and slowly infiltrates into the soil. During the on-site survey associated with the IAS, approximately 6 to 12 inches of water were ponded in this area. Also, during the IAS there were signs of surface erosion along the eastern embankment of the patrol road where there is a steep grade.

1.1.5 Site 10 - Southeast Open Disposal Area (A) Site 10 is contiguous to and south of Site 9 and located within the same old borrow pit area. The site covers an area of approximately 4 acres. The location of the site is shown on Figure 1-7. From 1965 to 1973, this site was used as an open disposal area for inert types of wastes such as construction debris (concrete, lumber, asphalt, etc.), trees, brush, metal cans, and similar material not suitable for landfill disposal.

The IAS reported that access to the site was uncontrolled and there are no records on the types of wastes disposed. Besides inert materials, other wastes potentially disposed at this site may have included wastes associated with the operation and maintenance of aircraft such as waste solvents, paint, oil, and hydraulic fluid. The IAS also reported that transformer oil, potentially contaminated with PCBs, was also disposed at this site. Empty pesticide and herbicide containers from the Pesticide Shop were also reportedly disposed at this site. Table 1-5 summarizes the types and quantities of wastes potentially disposed at Site 10. The site was covered after its closure in 1973, but construction rubble has been disposed at this site since this date.

A major portion of the surface runoff from Site 10 drains north to a depressed area associated with Site 9. Any runoff from the depressed area, along with the remaining area of the disposal site, is east toward Big Coldwater Creek, located approximately 1.9 miles to the east.

1.1.6 Site 11 - Southeast Open Disposal Area (B) Site 11 is located in the southeastern portion of the air station near the eastern property line (see Figure 1-3, Appendix A). A more detailed site plan is shown in Figure 1-8.

This 3-acre site was used as an open disposal area from the time NAS Whiting Field was established in 1943 until approximately 1970. Access to the site was

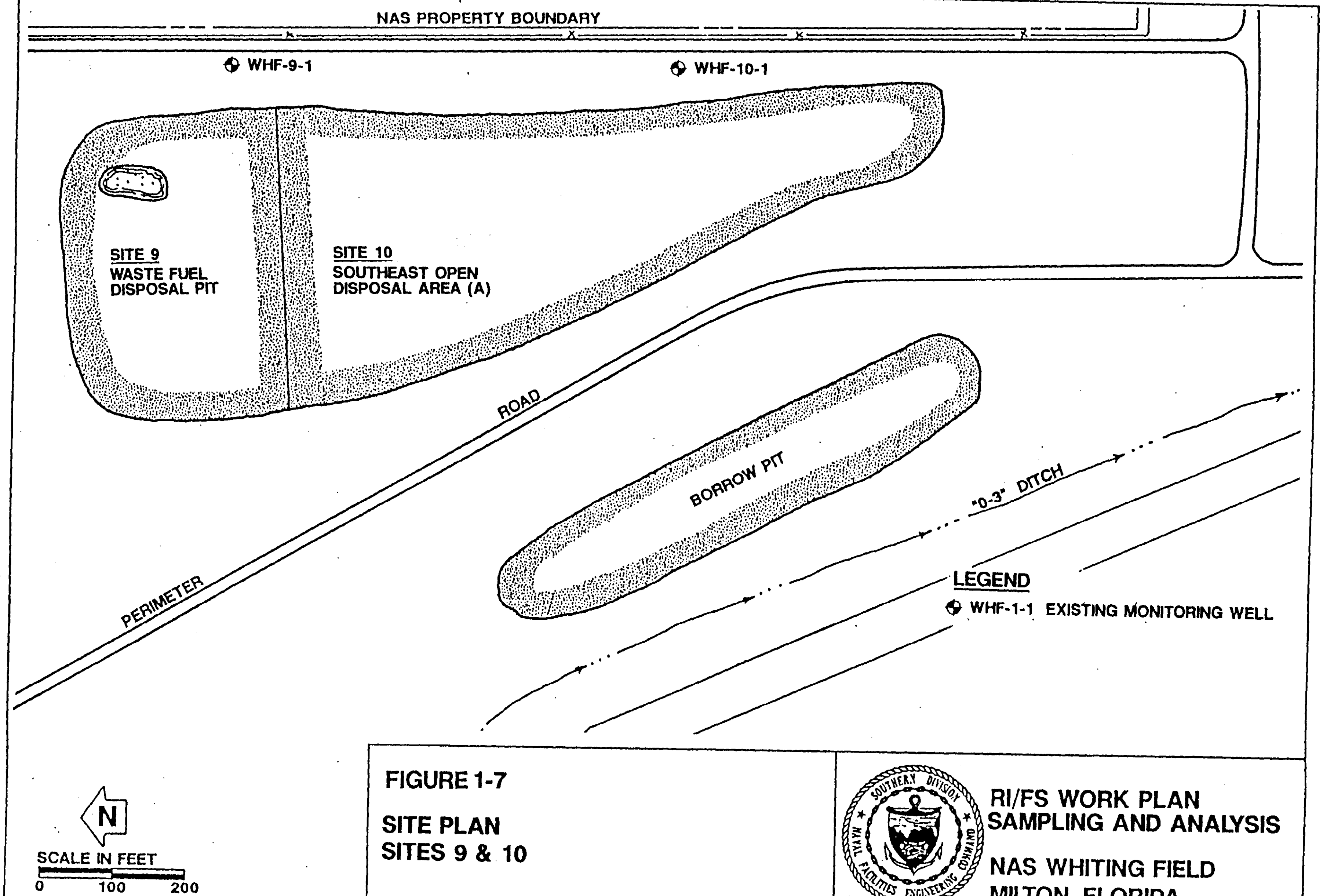


FIGURE 1-7

SITE PLAN
SITES 9 & 10

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

TABLE 1-5
WASTES POTENTIALLY DISPOSED AT SITE 10, SOUTHEAST OPEN DISPOSAL AREA (A)
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

WASTE	SOURCE OF WASTE	TIME PERIOD	ESTIMATED* TOTAL QUANTITY	COMMENTS
Construction and demolition debris	Naval Air Station	1965 to 1973	--	Site 10 was a secondary disposal area during this period. It was used primarily for the disposal of inert wastes.
Paint stripping wastewater	AIMD Paint Shop	1965 to 1973	40,000 gallons	Paint stripping wastes diluted significantly with copious amounts of rinse water.
Solvents (MEK, toluene, xylene, and PD-680)	Air Frame Shop, Aircraft Maintenance, Transportation Division Shop	1965 to 1973	5,000 gallons	**
Waste oils and hydraulic fluids	Operation Maintenance Division, Transportation Division Shop	1965 to 1973	8,000 gallons	*

Source: Envirodyne Engineers (1985)

NOTE: * - Assumes that 1/5 of the total maximum yearly waste generated was disposed at Site 10, and 4/5 was disposed at Site 15

** - Maximum quantity disposed at this site and Fire Fighting Training Area

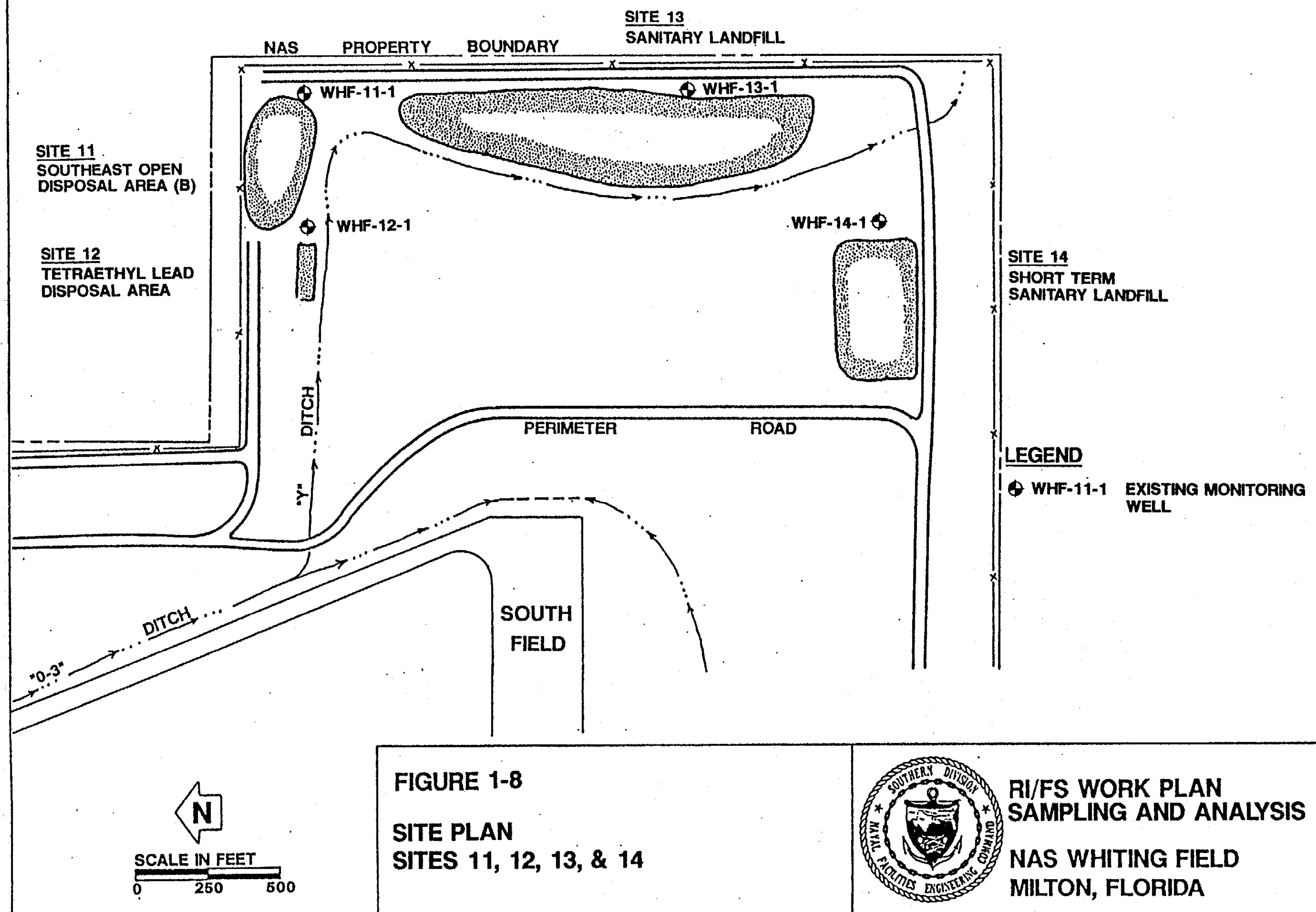


FIGURE 1-8

SITE PLAN
SITES 11, 12, 13, & 14

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

uncontrolled and there are no records on the types of wastes disposed. The site reportedly was used to dispose of a wide variety of wastes, which included general refuse, construction debris (concrete, asphalt, lumber, etc.), tree clippings, and furniture. Transformers, potentially containing PCBs, were also drained at the site. Wastes associated with the operation and maintenance of aircraft (paint, paint thinner, solvents, waste oils, and hydraulic fluid) may also have been disposed at the site. Table 1-6 summarizes the types and quantities of wastes potentially disposed at Site 11.

Disposal operations at the site were discontinued around 1970. At that time, a final covering was placed over the site and pine trees planted. Pine trees approximately 25 to 30 feet tall now occupy the site, with the exception of the northeastern portion. The areas surrounding the site are also pine covered.

The site slopes generally from south to north and from west to east. Surface runoff from the site is towards the northeastern corner where there is a low point. Runoff apparently ponds in this area. Any runoff from the site would continue in a northeasterly direction across the dirt access road which borders the site on the north. Surface runoff from the site ultimately drains to Big Coldwater Creek approximately 1.7 miles east of the site. A bermed area with pine trees borders the area on the east. Drainage ditch "Y" is located just south of the site, but does not receive runoff from the site. Groundwater flow in the area is in a southerly direction (Geraghty & Miller, 1986).

<u>1.1.7 Site 12 - Tetraethyl Lead Disposal Area</u> Site 12 is located in the southeastern part of the base and is just west of Site 11. The site location is shown in Figure 1-8.

Tank bottom and fuel filter sludges, containing tetraethyl lead, from the cleaning of the North and South Aqua System Fuel Storage Tanks were disposed of at Site 12 in May 1968. The disposal area consists of two earth-covered mounds within a fenced area which is approximately 50 feet by 25 feet. Each of the mounds is approximately 5 feet high and 10 feet in diameter and reportedly contains about 200 to 400 gallons of sludge in each mound.

The "Y" drainage ditch, which is not concrete lined, is located immediately adjacent to the southern border of the site and receives surface runoff from the area. The drainage ditch ultimately discharges to Big Coldwater Creek, approximately 1.7 miles east of the site.

<u>1.1.8 Site 13 - Sanitary Landfill</u> Site 13 is located on the eastern property line of South Field. This 4-acre site was the last operating landfill at NAS Whiting Field until it was closed in 1988. The location of the site is shown in Figure 1-8.

Landfill operations at the site began in 1979. Since 1979, this site received all the NAS Whiting Field's wastes which were disposed on-station except for construction and demolition debris, which is disposed at Site 2. The IAS reported that during the first year of operation (1979), wastes associated with the operation and maintenance of aircraft such as waste solvents, paint, oil, and hydraulic fluid were potentially disposed at the site. Asbestos wrapped in

TABLE 1-6
WASTES POTENTIALLY DISPOSED AT SITE 11, SOUTHEAST OPEN DISPOSAL AREA (B)
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

WASTE	SOURCE OF WASTE	TIME PERIOD	ESTIMATED* TOTAL QUANTITY	COMMENTS
General refuse	Naval Air Station	1943 to 1970	--	Site 11 was a secondary disposal area during this period (Site 16 was the primary).
Paint stripping wastewater	AIMD Paint Shop	1943 to 1970	100,000 gallons	Paint stripping wastes diluted significantly with copious amounts of rinse water.
Waste paints and thinners	Operations Maintenance Division	1943 to 1960	200 gallons	**After 1960, this waste went to the Fire Fighting Training Area.
Solvents (MEK, toluene, xylene, and PD-680)	Air Frame Shop, Aircraft Maintenance, Transportation Division Shop	1943 to 1970	20,000 gallons	**
Waste oils and hydraulic fluids	Operations Maintenance Division, Transportation Division Shop	1943 to 1970	30,000 gallons	**

Source: Envirodyne Engineers (1985)

NOTE: * - Assumes 3/10 of the total maximum yearly waste generated was disposed at Site 1, 1/5 was disposed at Site 11, and 1/2 was disposed at Site 16; (estimates rounded to one significant figure).

** - Maximum quantity disposed at this site and Fire Fighting Training Area

plastic was also disposed at the landfill. Table 1-7 summarizes the types and quantities of wastes potentially disposed at Site 13.

The vegetated "Y" drainage ditch borders the landfill to the west and south. The general topography in the area is from the northwest to southeast. However, the landfill is depressed from the surrounding ground level and runoff typically ponds onsite. In the event there is surface runoff from the site, it would drain toward Big Coldwater Creek, located approximately 1.7 miles east of the site.

1.1.9 Site 14 - Short-Term Sanitary Landfill Site 14 is located in the southeastern portion of the station near the end of abandoned runway 27 and close to Site 13. The location of Site 14 is shown in Figure 1-8. This site was used for 6 to 9 months starting in 1978 and continuing into 1979 as a sanitary landfill. The site was abandoned after this short time period due to excessive amounts of clay in the surface soil which caused water to pond throughout the site. Trucks delivering wastes were continually getting stuck, so the decision was made to relocate the landfill. During the short period of time the landfill was operating, waste solvents and residue from paint stripping operations may have been disposed at the landfill (Envirodyne Engineers, 1985). The majority of waste that were disposed at the site was general refuse and non-hazardous waste. Table 1-8 summarizes the types and quantities of wastes that were potentially disposed at Site 14.

Much of the central portion of Site 14 is unvegetated, with the area around the periphery of the site being grass or weed covered. The area surrounding the site is covered with pine trees. Access to the site is from the perimeter patrol road. The site generally slopes from west to east. Surface drainage from the area is in an easterly direction toward the vegetated "Y" drainage ditch which borders the site on the east. The ditch drains east towards Big Coldwater Creek which is located approximately 1.8 miles to the east. The site is poorly drained and shows obvious signs of surface erosion.

1.1.10 Site 15 - Southwest Landfill Site 15 is located southeast of the wastewater treatment plant on an area of approximately 15 acres (see Figure 1-3, Appendix A). A more detailed site plan is shown on Figure 1-9.

Site 15 was operated as a landfill from 1965 to 1979, during which time it received the majority of wastes generated at NAS Whiting Field. Wastes disposed included primarily general refuse plus other wastes associated with the operation and maintenance of aircraft (paint, paint thinner, solvents, waste oil, and hydraulic fluid). Disposal included wastes from the Aircraft Intermediate Maintenance Department (AIMD) and the training squadrons. Bagged asbestos was also reportedly disposed at the site, as well as potentially PCB-contaminated dielectric fluid (Envirodyne Engineers, 1985). The IAS estimated that 3,000 to 4,500 tons of waste were disposed at the site annually. Table 1-9 summarizes the types and quantities of wastes potentially disposed at Site 15. The site was operated as a landfill, with the waste material being covered on a daily basis. No burning was conducted at the site.

The site is located at the foot of the Western Highlands. The area has a surface slope of about 5 percent. The land slopes from east to west towards Clear Creek. Thus, surface runoff from the site is to Clear Creek, which is approximately

TABLE 1-7
WASTES POTENTIALLY DISPOSED AT SITE 13, SANITARY LANDFILL
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

WASTE	SOURCE OF WASTE	TIME PERIOD	ESTIMATED TOTAL QUANTITY	COMMENTS
General refuse	Naval Air Station	1979 to 1984	--	Site 13 was the primary landfill for the Naval Air Station during this period.
Paint stripping wastewater	AIMD Paint Shop	1979 to 1980	24,000 gallons	Paint stripping wastes diluted significantly with copious amounts of rinse water.
Solvents (MEK, toluene, xylene, and PD-680)	Air Frame Shop, Transportation Division Shop, Helicopter Maintenance	1979 to 1980	1,000 gallons	**
Waste oils and hydraulic fluids	Operations Maintenance Division, Transportation Division Shop	1979 to 1980	600 gallons	**

Source: Envirodyne Engineers (1985)

NOTE: ** - Maximum quantity disposed at this site and Fire Fighting Training Area

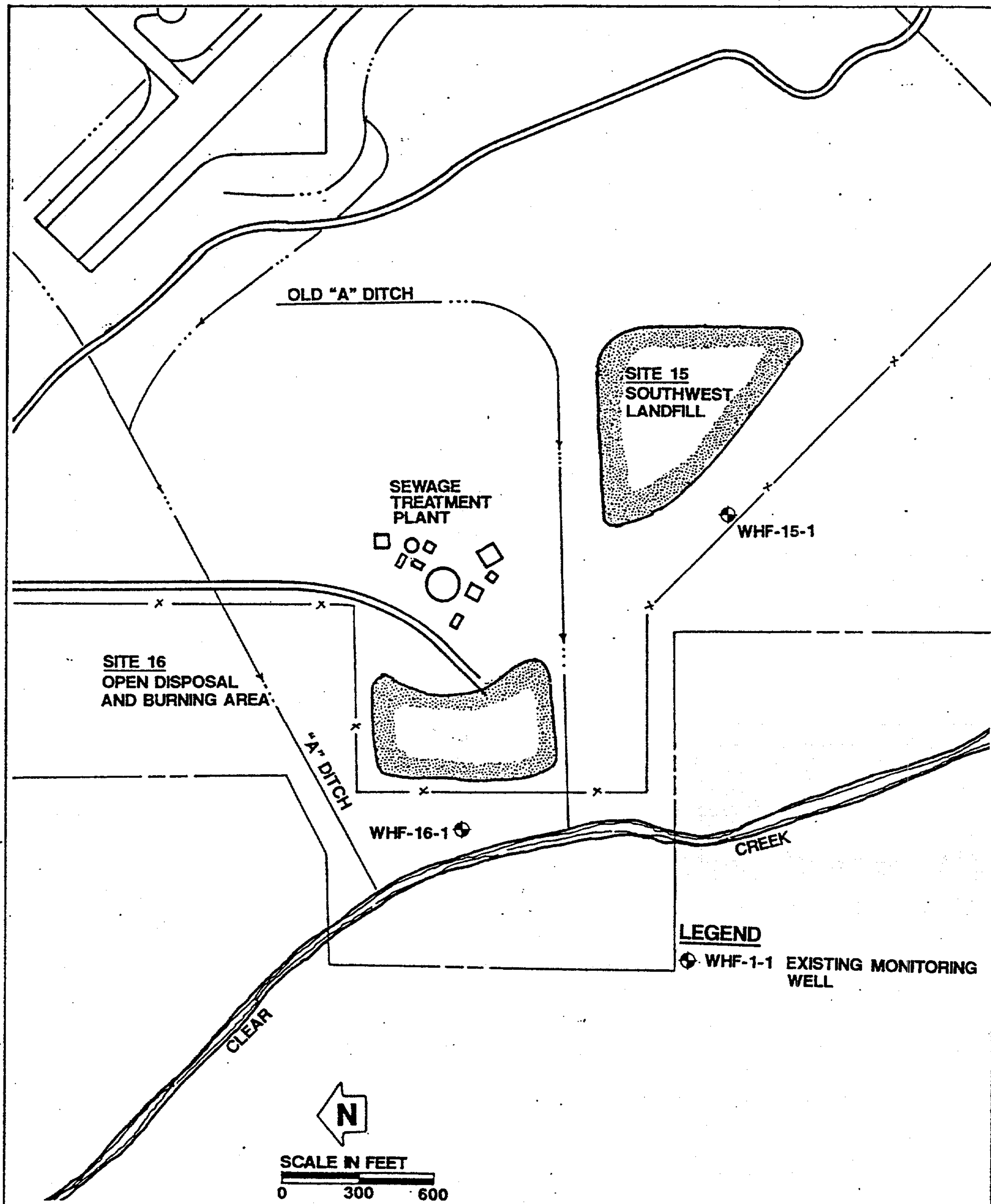


FIGURE 1-9

SITE PLAN
SITES 15 & 16

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

TABLE 1-8
WASTES POTENTIALLY DISPOSED AT SITE 14, SHORT-TERM SANITARY LANDFILL
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

WASTE	SOURCE OF WASTE	TIME PERIOD	ESTIMATED TOTAL QUANTITY	COMMENTS
General refuse	Naval Air Station	1978 to 1979	--	Site 14 was a primary landfill for this brief period; relocated due to drainage problems.
Paint stripping wastewater	AIMD Paint Shop	1978 to 1979	24,000 gallons	Paint stripping wastes diluted significantly with copious amounts of rinse water.
Solvents (MEK, toluene, xylene, and PD-680)	Air Frame Shop, Aircraft Maintenance, Transportation Division Shop	1978 to 1979	1,000 gallons	**
Waste oils and hydraulic fluids	Operations Maintenance Division and Transportation Division Shop	1978 to 1979	600 gallons	**

NOTE: ** - Maximum quantity disposed at this site and Fire Fighting Training Area
Source: Envirodyne Engineers (1985)

TABLE 1-9
WASTES POTENTIALLY DISPOSED AT SITE 15, SOUTHWEST LANDFILL
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

WASTE	SOURCE OF WASTE	TIME PERIOD	ESTIMATED* TOTAL QUANTITY	COMMENTS
General refuse	Naval Air Station	1965 to 1979	--	Site 15 was a primary landfill during this period.
Paint stripping wastewater	AIMD Paint Shop	1965 to 1979	300,000 gallons	Paint stripping wastes diluted significantly with copious amounts of rinse water.
Solvents (MEK, toluene, xylene, and PD-680)	Air Frame Shop, Aircraft Maintenance, Transportation Division Shop	1965 to 1979	40,000 gallons	**
Waste oils and hydraulic fluids	Operations Maintenance Division and Transportation Division Shop	1965 to 1979	60,000 gallons	**

Source: Envirodyne Engineers (1985)

NOTE: * - Assumes that 4/5 of the total maximum yearly waste generated was disposed at Site 15 and 1/5 was disposed at Site 10.
** - Maximum quantity disposed at this site and Fire Fighting Training Area

1,200 feet to the west of the site. The IAS reported that much of the site is covered with small pine trees; however, there are numerous areas void of vegetation. Severe surface erosion, as a result of the surface slope, was quite evident at the site during the IAS survey. The IAS also reported that the erosion problem was compounded by the fact that vegetative cover has not been fully established at the site. As a result of the erosion, some of the buried wastes have been exposed, including paint cans, oil filters, and spark plugs. Berms have been created throughout the landfill area to reduce surface erosion. The site is surrounded by tall pine trees.

<u>1.1.11 Site 16 - Open Disposal and Burn Area</u> Site 16 is located just east of Clear Creek and west of the wastewater treatment plant. The site covers an area of approximately 10 acres. The location of the site is shown in Figure 1-9.

Site 16 was used as an open disposal and burning area from the time NAS Whiting Field was established in 1943 until around 1965. During this period of time, the site reportedly received the majority of wastes generated at the air station. These wastes consisted of general refuse and wastes associated with the operation and maintenance of aircraft (paint, solvents, waste oil, and hydraulic fluid). This included wastes from AIMD and the training squadrons. The IAS also reported that PCB-contaminated dielectric fluid was probably disposed at the site. Approximately 3,000 to 4,500 tons of waste were disposed at the site annually. Table 1-10 summarizes the types and quantities of wastes potentially disposed at Site 16. Reportedly, the majority of wastes disposed at the site were burned for volume reduction. Waste diesel fuel was added to the wastes to promote burning.

The waste disposal area is located on a small plateau on the bank of Clear Creek and is at an elevation of approximately 50 feet above the National Geodetic Vertical Datum of 1929 (NGVD). To the east of the site lies the Western Highlands of the coastal plain. To the west the land drops to Clear Creek at a slope of about 10 percent. Clear Creek is located approximately 200 feet west of the site. The majority of the site and surrounding area is covered with pine trees.

Due to its topographic setting, the site collects surface runoff from areas to the east. Surface runoff from the site is towards Clear Creek. Due to the close proximity of the site to Clear Creek, surface runoff is quickly discharged to the creek. The groundwater flow in the area of the site is expected to follow that of surface water, flowing from east to west toward Clear Creek.

<u>1.1.12 Site 17 - Crash Crew Training Area</u> Site 17 is located in the North Field approximately 1,750 feet north of the "E" drainage ditch as shown in Figure 1-4. During the past 27 years, Site 17 has been used for fire fighting training. The specific training locations have been relocated within the boundaries of the site on several occasions. During a training session, approximately 110 gallons of JP-4 fuel is poured into shallow surface depressions, ignited, and then extinguished using an aqueous film-forming foam (AFFF). As an indication of volumes of materials used during these exercises, NAS Whiting Field records (as presented in the Verification Study) state that 6,285 gallons of fuel and 3,148 gallons of AFFF were used during 1984 between the two fire training areas (Sites 17 and 18).

TABLE 1-10
WASTES POTENTIALLY DISPOSED AT SITE 16, OPEN DISPOSAL AND BURN AREA
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

WASTE	SOURCE OF WASTE	TIME PERIOD	ESTIMATED* TOTAL QUANTITY	COMMENTS
General refuse	Naval Air Station	1943 to 1965	--	Site 16 was a primary disposal area during this period, Site 1 the secondary.
Paint stripping wastewater	AIMD Paint Shop	1943 to 1965	300,000 gallons	Paint stripping wastes diluted significantly with copious amounts of rinse water.
Waste paints and thinners	Operations Maintenance Division	1943 to 1965	500 gallons	**After 1960, this waste went to the Fire Fighting Training Area.
Solvents (MEK, toluene, xylene, and PD-680)	Air Frame Shop, Aircraft Maintenance, Transportation Division Shop	1943 to 1965	40,000 gallons	**
Waste oils and hydraulic fluids	Operations Maintenance Division, Transportation Division Shop	1943 to 1965	70,000 gallons	**

Source: Envirodyne Engineers (1985)

NOTE: * - Assumes that 1/5 of the total maximum yearly waste generated was disposed at Site 16, 3/10 was disposed at Site 1, and 1/5 was disposed at Site 11. Estimates rounded to one significant).

** - Maximum quantity disposed at this site and Fire Fighting Training Area

1.1.13 Site 18 - Crash Crew Training Area Site 18 is located on the southwest fence line of the North Field as shown in Figure 1-4. The background of Site 18 is identical to that of Site 17, which was described previously. The site has been used as a fire fighter training area for the past 27 years.

1.2 NAS WHITING FIELD - PHYSICAL SETTING.

1.2.1 Topography, Surface Water, and Drainage Santa Rosa County lies within the Coastal Plain Province. The county is divided into two main physiographic divisions, the Western Highlands and the Gulf Coast Lowlands. Most of Santa Rosa County, including NAS Whiting Field, lies within the Western Highland, which is characterized as a well drained southward sloping plateau with numerous streams.

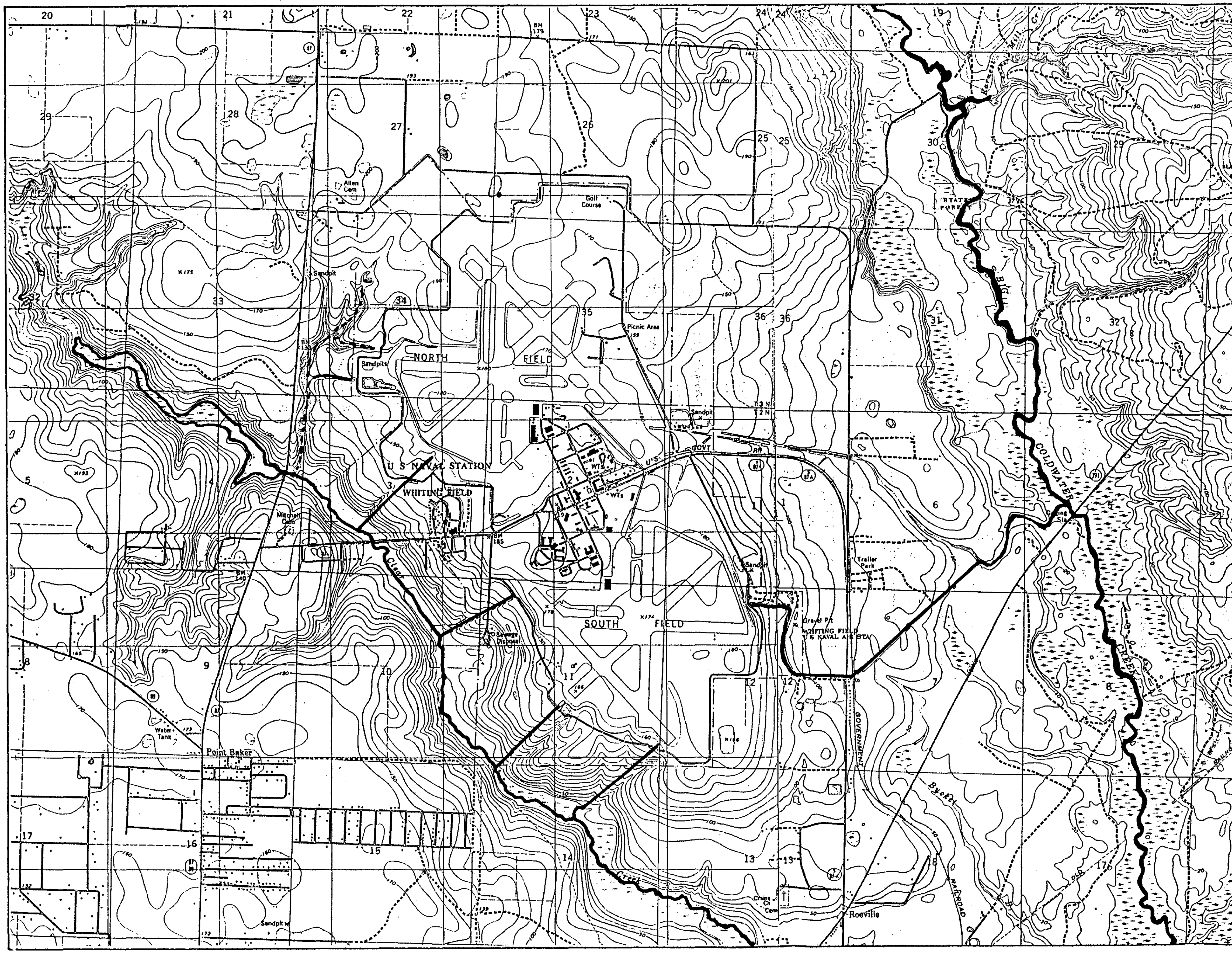
NAS Whiting Field is located on an upland area with elevations ranging from 150 to 190 feet above NGVD. The facility is bounded by Clear Creek, to the west and south, and Big Coldwater Creek, to the east. These two creeks are tributaries to the Blackwater River, which is located to the south. Clear Creek and Big Coldwater Creek are classified by the FDER as Class III Surface Waters and the Blackwater River is classified as an Outstanding Florida Water. Outstanding waters are considered to be of exceptional recreational and ecological significance.

Because of the relatively steep valley slopes and the 100 ± foot drop in elevation between NAS Whiting Field and the receiving creeks, erosion was a serious problem when the original land surface was disturbed during construction of the base. Soil conservation measures in the form of extensive contouring and construction of large paved ditches were instituted to control surface runoff from the upland area of the base. This system of ditches conveys surface runoff to Clear Creek and Big Coldwater Creek. These and other surface water drainage features are shown in Figure 1-10.

1.2.2 Geology The region is located in the Coastal Plain Province, which consists primarily of unconsolidated sands, silts, limestones, and clays of Cretaceous to recent age. The regional geologic sequence found in this area is illustrated in Figure 1-11 (Marsh, 1966). A geologic cross-section through NAS Whiting Field is shown in Figure 1-12.

1.2.3 Soils The soils at NAS Whiting Field are sandy with a loamy subsoil and belong to the Troup-Dothan-Bonifay map unit. They are characterized as gently sloping to strongly sloping, well-drained soils. This map unit covers about 27 percent of Santa Rosa County and consists of 53 percent Troup soils, 15 percent Dothan soils, 12 percent Bonifay soils, and 20 percent soils of minor extent. An in-depth description of the various soil types identified in the soils map can be found in the soil survey of Santa Rosa County (Soil Conservation Service, 1980).

1.2.4 Hydrogeology Musgrove et al. (1965) describe three major groundwater aquifers within the region. The first is a shallow aquifer (sand and gravel aquifer), which is both artesian and non-artesian. The two others are deep artesian aquifers (upper Floridan limestone aquifer and lower Floridan limestone aquifer). Virtually all groundwater withdrawn in Escambia and Santa Rosa Counties comes from the sand and gravel aquifer. Descriptions of the aquifers



N

SCALE IN FEET

0 3000 6000

SOURCE:
USGS QUADRANGLE MILTON NORTH, FLORIDA
PHOTOREVISED 1987
AND USGS QUADRANGLE HAROLD, FLORIDA 1973.

FIGURE 1-10

DRAINAGE FEATURES

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

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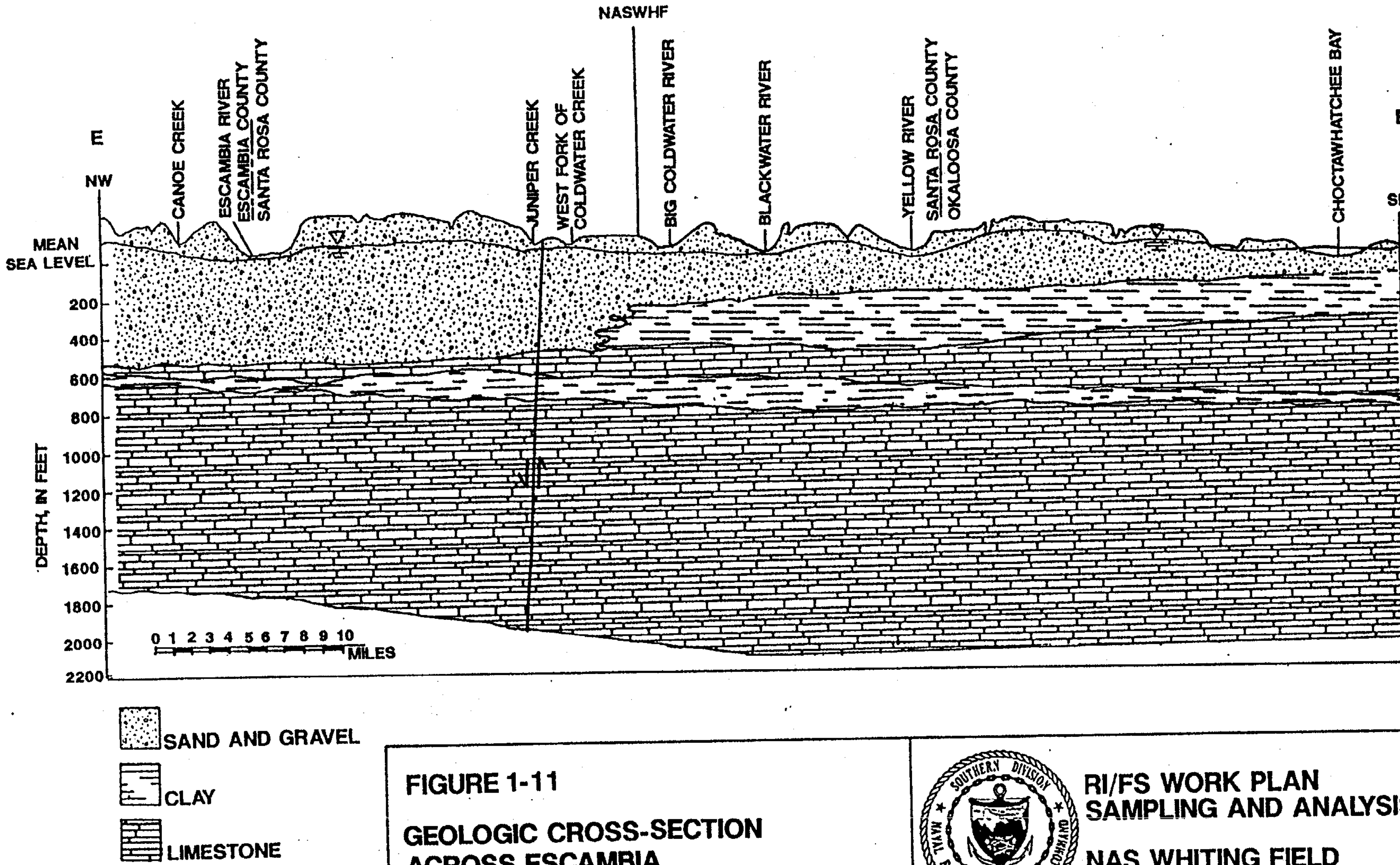


SOURCE: MARSH (1966)

FIGURE 1-11

GEOLOGIC CROSS-SECTION ACROSS ESCAMBIA AND SANTA ROSA COUNTIES

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

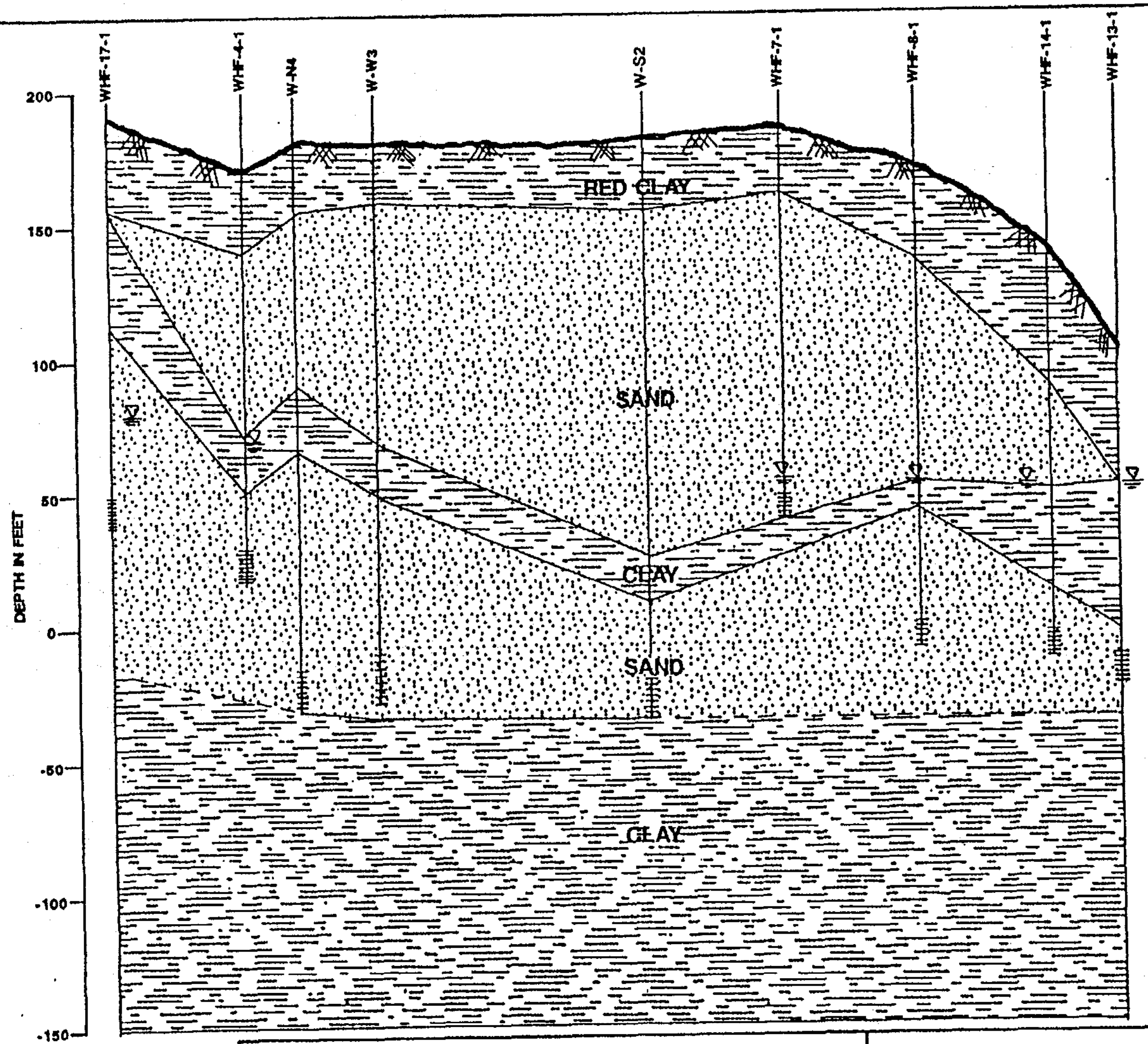


FIGURE 1-12

GEOLOGIC CROSS-SECTION ACROSS NAS WHITING FIELD

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

(as presented in the Verification Study, Geraghty & Miller, 1986) are as follows.

- Sand and Gravel Aquifer. The uppermost sediments, extending to a depth of about 350 feet BLS, comprise the sand and gravel aquifer which is subdivided into two units. The water table or upper zone of the sand and gravel aquifer does not constitute a source for large water supplies; however, its primary importance is to recharge the lower, more productive zone of the aquifer. According to an aquifer test in the Milton area, the clayey sand confining unit separating the upper and lower aquifer zones is very leaky. Most large capacity wells in the area, such as the NAS Whiting Field's potable supply wells, are screened into the lower zone of the sand and gravel aquifer from about 180 to 330 feet below land surface (BLS).

  The formation contains lensatic zones within the sand which are cemented by iron-oxide minerals. The lenses, known locally as hardpan, have lower permeabilities and, along with the clay lenses, are responsible for the occurrence of perched water tables and semi-artesian conditions in the aquifer. In the NAS Whiting Field area, clay lenses occur in the uppermost 30 feet and in the depth interval of approximately 100 to 170 feet BLS (elevation 10 to 70 feet above NGVD).

  The water from the sand and gravel aquifer is considered to be of excellent quality. Total dissolved solids and total hardness are generally less than 50 milligrams per liter (mg/l). However, because of high levels of dissolved carbon dioxide, the water is acidic with an ambient pH as low as 5.0. Locally, groundwater contains high concentrations of iron.

- Floridan Aquifer. Underlying the sediments of the sand and gravel aquifer is the thick ($300^{\pm}$ feet), relatively impermeable, Pensacola Clay, below which are thick layers of limestone and shale to a depth of nearly 2,000 feet.

  The limestone layers constitute the regionally extensive Floridan aquifer which, in this area, is divided into an upper and lower part separated by the Bucatunna Clay. The upper Floridan aquifer is an important source of water in areas east of Santa Rosa County; however, toward the west, it is increasingly mineralized and is generally not suitable for a water supply. The lower Floridan aquifer is highly mineralized in the NAS Whiting Field area and is, in fact, designated for use as a waste disposal injection zone. The Floridan aquifer receives little or no recharge from the sand and gravel aquifer because of the Pensacola Clay confining unit. The potentiometric surface of the Floridan aquifer in the NAS Whiting Field area is about 50 to 55 feet NGVD and the direction of flow is southeast.

2.0 SITE MANAGEMENT PLAN (SMP)

This section provides general operating guidelines for access, security, and the field team organization that will be implemented during RI activities.

2.1 SITE CONTROL.

2.1.1 Site Access Access to the base in general and to any restricted areas will be with one security pass per vehicle. All information on personnel involved in the project and a copy of the contract for the project will be provided to security at least 2 weeks before the field work begins.

General site layout and sample collection locations are presented in the Field Sampling Plan (FSP) (Section 3.0). Exploration and sampling stations are located both onsite and offsite. NAS Whiting Field will be responsible for obtaining keys to gates and locking caps of existing monitoring wells for those areas on the station.

It is anticipated that limited access improvements to boring locations will be required in the wooded areas adjacent to the landfills. The drilling subcontractor will be responsible for boring location access improvements including brush removal and tree cutting. Such access improvements will be cleared beforehand with NAS Whiting Field. Sampling locations and routes of access will be staked and marked with flagging to facilitate locating sampling sites during future investigative activities.

2.1.2 Site Security It is anticipated that full security (i.e., fencing) cannot be established at any of the drilling locations. Therefore, at active boring locations, open casings will be secured overnight by fastening the rotary drive head over the upper end of the casing. Finished monitoring wells will be secured by the installation of protective casings over well risers. The steel protective casings will be fixed in the ground with concrete and equipped with locking caps. The Field Operations Leader in conjunction with personnel from the Public Works Department will have the prime responsibility of providing secure areas for samples, waste materials, and equipment storage.

2.1.3 Communications Field personnel will use telephones while on the base to communicate with off-base parties and will have a list of emergency phone numbers available at all times. Personnel conducting on site work in one area of the NAS Whiting Field will use two-way radios with frequencies approved by the Navy to maintain a communication link with personnel working in other areas. Daily communications for access needs and scheduling site operations will be coordinated with one representative from the Public Works Department, NAS Whiting Field. As of this writing, the representative from the NAS Whiting Field will be Ms. Cindy Black.

2.1.4 Field Operations Drill rigs will either be left in a secured area or be disabled each night before personnel leave a site. Final approval for boring locations will be given during a site reconnaissance prior to the beginning of the field work. Potable water, which is necessary for drilling and decontamination procedures, will be obtained at fire hydrant locations specified by NAS Whiting Field's Public Works Department.

2.1.5 Decontamination Facilities The field work at the NAS Whiting Field sites will require mobilization and field support by subcontractors, sampling crews, and survey crews. Staging and decontamination facilities will be needed to conduct these operations. Staging of field operations will be done from vehicles used by site investigation personnel and subcontractors. These vehicles will be parked in uncontaminated areas identified for each site and will not require decontamination.

Decontamination zones for personnel and equipment will be established during the reconnaissance for each site. All contaminated materials and protective gear will either be disposed of or decontaminated in these areas before site personnel proceed to the clean zone.

A heavy equipment decontamination zone will be designated for each site. Drill rigs, casing, rods, and associated downhole equipment plus well casing and screen will be decontaminated and steam cleaned prior to setting up at each boring or monitoring well location. In addition, the drill rig and all tools will be decontaminated prior to entering and leaving NAS Whiting Field. Sampling tools will be decontaminated more frequently as required by the sampling protocol provided in Section 6.3 of the Quality Assurance Program Plan (Appendix B).

2.1.6 Disposal of Wastes All fluids generated by personnel and by equipment decontamination will be disposed of onsite, inside the contamination reduction area. Contaminated items such as disposable safety and sampling equipment will be placed in doubled plastic bags which will be collected daily and stored in Department of Transportation (DOT) approved 55-gallon drums with locking ring lids. The drums will be supplied by NAS Whiting Field and left onsite for future transportation by the Department of the Navy, Defense Reutilization and Marketing Office to a suitable disposal facility. This will be coordinated with NAS Whiting Field's Environmental Coordinator.

Drill fluids, drill cuttings, and water resulting from monitoring well and piezometer installation and development will be monitored for contamination using a portable photoionization or flame ionization meter. All borehole cuttings and development water will be contained in DOT 17-C open-top, 55-gallon drums, permanently labeled by well number and stored in a location designated by the NAS Whiting Field's Environmental Coordinator. This requirement may be waived if approval is given in writing by Southern Division's Engineer in Charge (EIC). The Navy will be responsible for disposal.

2.2 PROJECT ORGANIZATION AND MANAGEMENT. Figure 2-1 shows the program organization and its principal lines of communication for the NAS Whiting Field RI/FS. The responsibilities of the Jordan program positions and support organizations are summarized below.

Regional Officer. The Regional Officer (RO) is James R. Wallace, P.E., Southeast Division Manager. He is responsible for establishing a contract for the services to be performed and for committing the corporate resources necessary to conduct the program work activities; for supplying corporate-level input for problem resolution; and for assisting the Program Manager, Project Manager, and Technical Director as needed during project implementation.

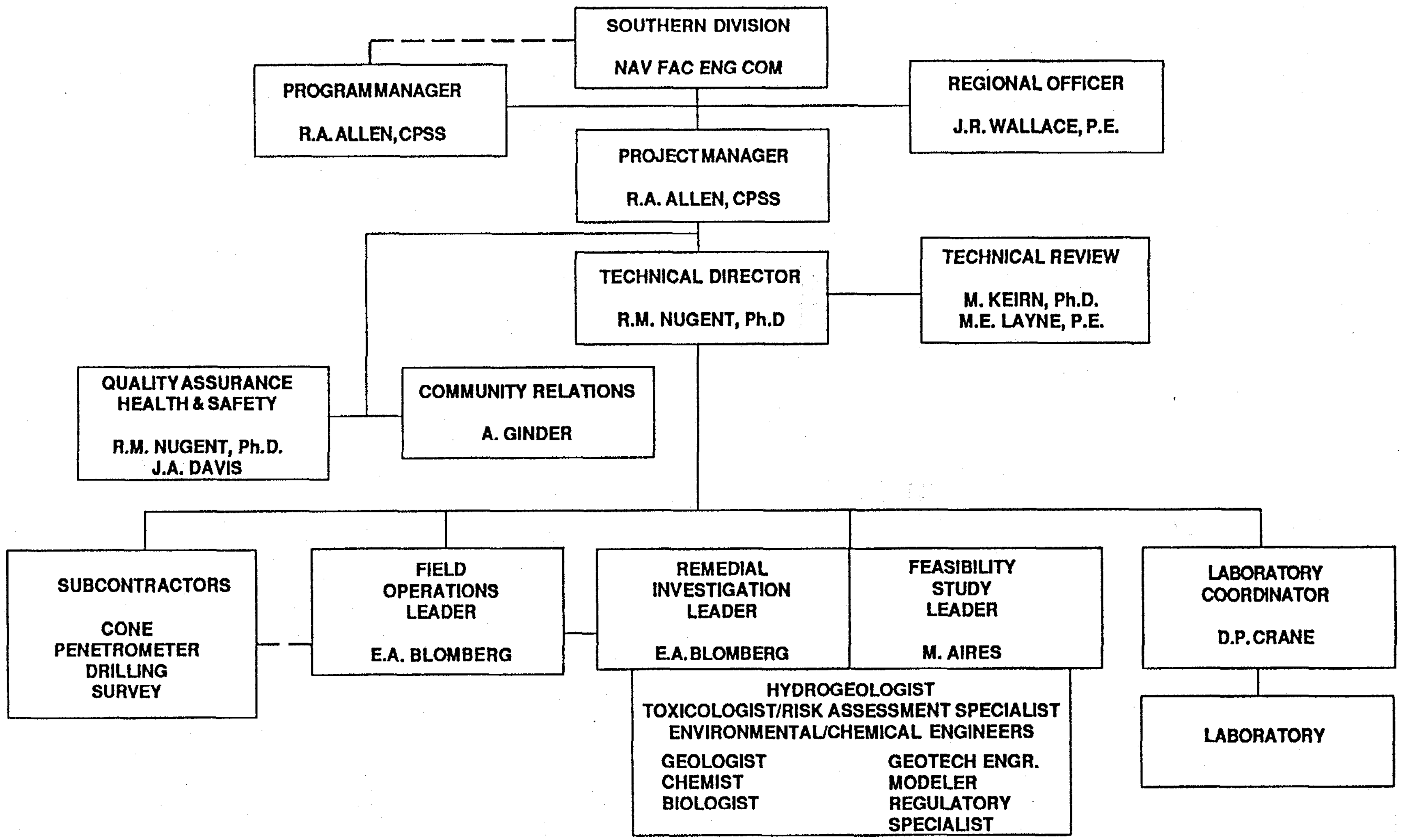


FIGURE 2-1

PROJECT ORGANIZATION

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

Program Manager. The Program Manager (PM), R. Anthony Allen, III, CPSS, is responsible for the overall Southern Division program. Some specific responsibilities of his role include:

- overall technical responsibility for the program;
- establishing and overseeing all subcontracts for support services;
- initiating program activities;
- implementing the subcontracting plan to significantly involve small and disadvantaged business in the program;
- participating in the work plan preparation and staff assignments;
- identifying and fulfilling equipment and other resource requirements;
- monitoring task activities to ensure compliance with established budgets, schedules, and the scope of work;
- regularly interacting with the IR Program EIC, the Facility Commanding Officer, and others, as appropriate, on the status of the project;
- preparing monthly technical/management/cost progress reports; and
- ensuring that appropriate financial record and reporting requirements are met.

Project Manager. Mr. Allen will also hold the position of Project Manager (PrM) for the NAS Whiting Field RI/FS. This position is established because of the importance of the day-to-day scope, schedule, and budget monitoring both within Jordan and between Jordan and the Navy's IR Program Engineer in Charge (EIC). It is expected that program decisions will be occurring frequently; therefore, it is necessary to anticipate and immediately implement the administrative actions (initiate internal work orders, follow-up on support needs, amend subcontracts, track cost and charges) to carry out the program plans.

Technical Director. Each facility investigated under the IR Program will be assigned a Technical Director (TD). Mr. R. Michael Nugent, Ph.D., has been assigned the TD for NAS Whiting Field.

The TD is responsible for the following:

- the appropriateness and adequacy of the technical or engineering services provided;
- developing the technical approach and level of effort required to address each of the tasks/subtasks;
- the day-to-day conduct of the work, including the integration of the input of supporting disciplines and subcontractors (i.e., drilling and laboratory subcontractors);

- ongoing quality control during performance of the work; and
- the technical integrity as well as the clarity and usefulness of all project work products.

Technical Review Board. A Technical Review Board (TRB), made up of senior technical staff from the Jordan team, will assist the PrM and TD by providing review of the technical aspects of the project to assure that the services reflect the accumulated experience of the firm; that they are produced in accordance with the corporate policy; and that they meet the intended needs of the IR Program's EIC. The primary function of this board is to assure the application of technically sound methodologies and the development of litigatively defensible data, interpretations, and conclusions. Members of the TRB are Mr. Michael Kiern, Ph.D. and Ms. Margaret Layne, P.E.

Quality Assurance/Health and Safety Coordinators. The PrM is supported by a Quality Assurance Officer (QAO) and a Health and Safety Officer (HSO). The QAO will assure that appropriate IR Program and USEPA protocols are followed and will be responsible for the development of the Site-Specific Quality Assurance Plan Addendum. The QAO will work with the PrM/TD to ensure that established quality control procedures are implemented. The HSO is responsible for ensuring that the project team complies with the Health and Safety Program. He is also responsible for seeing that a Health and Safety Plan is developed for each site activity.

Other key line positions are the technical activity leaders, i.e., the senior or most-experienced individual in each technical area of the project. These technical activity leaders are identified on the Project Organization Chart.

The following is a list of key project staff. Revisions and identification of additional personnel may be made prior to the initiation of RI activities. A list of emergency numbers is also contained in the HASP.

E.C. Jordan Co.
Tony Allen, Program Manager & Project Manager
Michael Nugent, Technical Director, QAO
Jack Davis, HSO
Eric Blomberg, RI Leader, Field Operation Leader (FOL)
Michael Aires, FS Leader

Southern Division
Ted Campbell, Engineer in Charge

NAS Whiting Field
Cindy Black, Environmental Coordinator

2.3 SCHEDULE. The Project Schedule illustrated in Figure 2-2 shows the tasks and activities for the NAS Whiting Field RI field investigation. This schedule will begin upon the approval of the Work Plan and the Notice to Proceed. At that time, the schedule will be revised so that real dates replace the numbered weeks. The schedule assumes ready access to the sites. The schedule also assumes there will be no delays due to the securing of required permits.

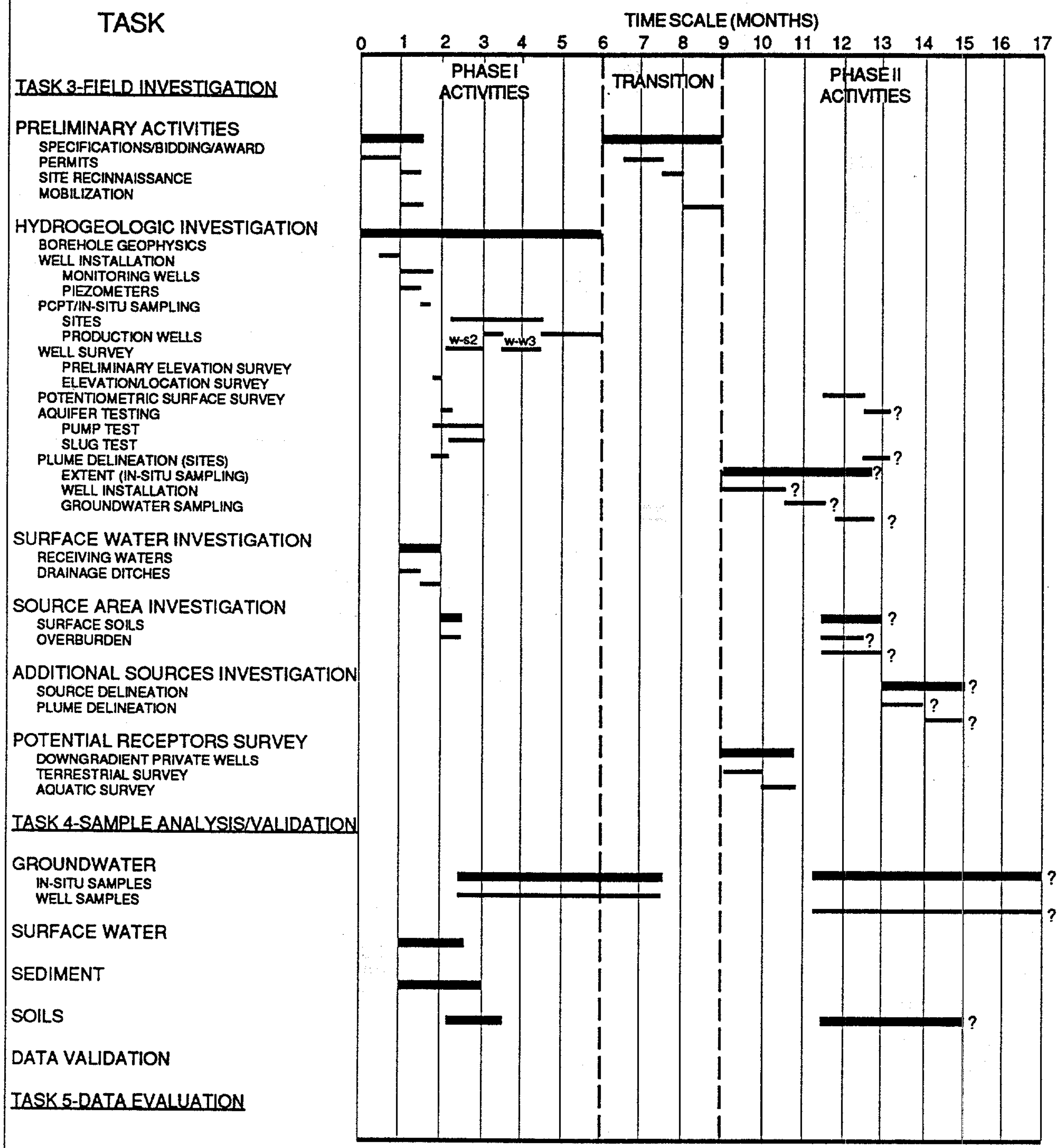


FIGURE 2-2

ANTICIPATED PROJECT SCHEDULE RI FIELD INVESTIGATION

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

3.0 FIELD SAMPLING PLAN (FSP)

The Phase I RI field program as presented in this Field Sampling Plan has been designed to provide the necessary data required to meet the objectives of the NAS Whiting Field RI/FS (see Section 3.4 of the Work Plan, Volume I). The objectives of the field investigation are as follows:

- locate contaminated source areas;
- assess the nature and extent of contaminants found in soil, groundwater, surface water, and sediments;
- characterize regional and local hydrogeology;
- provide the data base to undertake the risk assessment; and
- obtain the required data to evaluate remedial alternatives.

Table 3-1 presents the activities to be undertaken to achieve these objectives.

The investigations have been planned using existing data (see Work Plan Section 2.3.5) as a basis for the numbers and locations of the investigative tasks. Adjustments to the proposed investigations may be made during the RI as additional data become available. Such adjustments will result from discussions among the Field Operations Leader, the Project Technical Director, and Southern Division's Engineer in Charge.

3.1 GENERAL SITE OPERATIONS.

3.1.1 Field Technical Guidance The purpose of the RI is to collect data characterizing the nature and distribution of contamination at the 13 NAS Whiting Field sites and to provide an adequate database for the performance of an FS. The basic requirement for all work conducted under the Navy's IR Program is that data collected maintain consistent quality. Data must be precise, accurate, representative, complete, and comparable. To meet these objectives, site activities will be conducted under the guidance of field program's Quality Assurance Program Plan (QAPP) as presented in Appendix B of this Volume II. USEPA and Navy technical guidance documents will also be used when guidance for a specific task is not provided in the QAPP. These guidance documents are referenced whenever possible in the description of the field procedures. Copies of the referenced sections of the guidance documents along with this SAP will be maintained in the field trailer and reviewed with the field team before the start of each task. It is the responsibility of the FOL to acquaint field personnel with procedures to undertake the RI field investigation.

3.1.2 Field Personnel Responsibilities The field team for the RI activities will work under the direction of the TD and RI Task Leader and will consist of the following personnel.

- Field Operations Leader. Responsible for day-to-day review of the field activities performed on-site, overall management and coordination of the field work, and supervision and scheduling of work. The FOL will maintain

TABLE 3-1
RI FIELD INVESTIGATION TASKS
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

TASK CODE	TASK DESCRIPTION	PHASE
30.00	Task 3 - Field Investigation	
31.00	Preliminary Activities	
31.10	Specifications/Bidding/Award	I, II
31.20	Permitting	I, II
31.30	Site Reconnaissance	I
31.50	Mobilization	I, II
33.00	Hydrogeologic Investigation	
33.10	Borehole Geophysics	I
33.20	Monitoring Well/Piezometer Installation	
33.21	Background Monitoring Wells	I
33.23	Piezometers	I
33.26	Confirmation Wells	I
33.30	PCPT Exploration/*In-Situ* Sampling and Analysis	
33.31	Site Investigation	I
33.36	Production Wells Investigation	I
33.40	Well Measuring Point Survey	
33.41	Elevation Survey (Preliminary)	I
33.46	Elevation/Location Survey	II
33.50	Potentiometric Surface Survey	I,II
33.60	Aquifer Hydraulic Properties Test	
33.61	Pump Test	I
33.66	Slug Test	I, II
33.70	Contaminant Plume Delineation	II
33.71	*In-situ* Groundwater Sampling	II
33.73	Downgradient Monitoring Wells	II
33.75	Groundwater Sampling	II
34.00	Surface Water/Sediment Investigation	
34.10	Receiving Waters	I
34.60	Drainage Ditches	I
35.00	Source Area Investigation	
35.10	Surface Soils	II
35.20	Overburden	II
36.00	Additional Sources Investigation	
36.10	Source Delineation	II
36.60	Plume Delineation	II
37.00	Potential Receptors Survey	
37.10	Downgradient Private Wells	II
37.40	Terrestrial Survey (Habitat & Biota)	II
37.70	Aquatic Survey	II

consistency and require that field teams follow project-specific plans and that the implementation of field investigations are in compliance with appropriate guidelines.

- Field Geologist. Responsibilities include overseeing boring and monitoring well activities, including the appropriate logging and documentation; ensuring that standard and approved drilling and monitoring well installation methods are followed; and ensuring that pertinent drilling and testing information is obtained during drilling.

- Project Hydrologist. Responsible for planning and overseeing groundwater measurements and tests so that appropriate and valid results are obtained; determining the number of data points, wells, and reference measuring points needed to adequately define groundwater flow and enable groundwater contour mapping; and assessing the groundwater flow regime and identifying subsurface conditions that would affect flow.

- Sampling Team Leader. Responsibilities include monitoring procedures and requirements related to sampling and chain-of-custody according to appropriate guidelines.

- Field Analyst(s). Responsibilities include onsite gas chromatograph (GC) analyses including calibration, quality control, recording of results, and maintenance of the field equipment.

- Sampling Personnel. Responsible for the proper collection, preservation, packaging, documentation, and initial chain-of-custody of samples until released to another party for storage or transport to the analytical laboratory.

- Health and Safety Officer. Responsible for monitoring activities during site work and enforcing the HASP. The HSO will have the authority to stop work if conditions exceed allowable limits and, as appropriate, will assume certain sampling responsibilities.

- Health and Safety Officer Designee. For this task, the project HSO may not be onsite at all times. Therefore, a sampling team member will be designated to monitor procedures and report inconsistencies to the HSO. Designee will have power to stop work should conditions exceed allowable limits.

- Drilling Subcontractor. Responsible for obtaining drilling permits and clearances; supplying all services (including labor), equipment, and materials required to perform the drilling, testing, and well installation program; and conducting necessary maintenance and quality control of required equipment. The drilling subcontractor will be responsible for following decontamination procedures specified in the SAP and HASP. Upon completion of the work, the drilling subcontractor will be responsible for demobilizing all equipment, cleaning up any materials deposited onsite during drill operations, and properly backfilling or grouting any borings.

- Other Subcontractors. Survey subcontractors will also be onsite and will be responsible for completion of their respective activities.

It should be noted that field team members will assume the duties of several of the positions described above.

3.1.3 Personal Protection A site-specific HASP has been prepared as part of the RI/FS Work Plan (Volume III). Section 8.2 of the HASP, Personal Protection provides information regarding the required levels of protection for various tasks. Section 11 of the HASP details personal decontamination procedures.

3.1.4 Mobilization Activities Following Southern Division approval of the FSP and issuance of a written Notice to Proceed, arrangements will be made to place a command post onsite, schedule a field sampling crew, and have sampling and health and safety equipment shipped to the site. Provisions for electrical power and a telephone will also be made.

Additional mobilization activities will include familiarizing the sampling crew with this FSP and applicable field technical guidelines prior to initiating the investigation.

3.1.5 Sample Identification and Chain of Custody All samples collected during the field investigation will be labeled with a sample identification code that identifies the site, sample type, sample location, and series numbers for sample locations with multiple samples.

The samples at the NAS Whiting Field (WHF) sites will be labeled using the following system:

- Site. Always WHF-XXX, where "XXX" refers to the site number, production well number, or stream sampling location.

- Sample Type.

MW - Monitoring Well	SD - Sediment
RW - Residential Well	SW - Surface Water
WP - Well Point	AR - Air (residential)
SL - Surface Soils	BN - Benthos
SS - Subsurface Soils	FB - Field Blank
SG - Soil Gas	TB - Trip Blank
	EB - Equipment Blank

- Sample Location. Sample locations will be indicated by a number that corresponds to the sample collection location and will be used in combination with the sample type. For example, sample WHF-XXX-SW-3 is a surface water sample collected at location 3 as shown on a Site Plan for Site XXX.

- Sample Number. For circumstances where multiple samples will be collected from the same location, each sample will be consecutively numbered. For example, WHF-XXX-SW-3-01 and WHF-XXX-SW-3-02 are surface water samples collected at the same location but at different times. For soil borings, the number designating the boring location will be followed by a sample depth range in parenthesis. A sample collected at WHF-XXX-SS-01 from a depth interval of 4 to 5 feet BLS would be designated:

WHF-XXX-SS-01(4-5)-1

For duplicates, a letter designation will be used for the duplicate sample. For example, the duplicate of WHF-XXX-SS-01(4-5)-1 will be:

WHF-XXX-SS-01(4-5)A-1

If a duplicate is taken at that point again, the number would become:

WHF-XXX-SS-01(4-5)A-2

Chain-of-custody procedures as outlined in Section 7.0 of the QAPP will be followed during all RI activities.

3.1.6 Sample Container Requirements, Preservation, and Holding Times Sample container, preservation, and holding time requirements are specified in Section 6.0 of the QAPP. Samples requiring preservation will be preserved immediately following collection.

3.1.7 Sample Packaging and Shipping Samples will be packaged and shipped in accordance with procedures presented in Section 7.2 of the QAPP. The FOL will be responsible for coordinating with the Laboratory Coordinator (LC), who will contact the analytical laboratory for each shipment of samples.

The LC will be contacted at least 1 week before each sampling episode and arrangements will be made to have spikes and trip blanks prepared and picked up. The LC will be informed of any changes in the number and types of samples as the changes occur. The analytical laboratory will be contacted on the day of each shipment of samples and provided with the following information:

- dates the samples were shipped,
- types of samples,
- number of samples, and
- airbill number.

For purposes of scheduling, the analytical laboratory will track sample shipment, receipt, and analysis and will be responsible for forwarding this information to the LC who will then forward copies to Southern Division's Engineer in Charge.

3.1.8 Documentation Bound, weather-proof field notebooks will be maintained by the field team. Team members shall record all information related to sampling time, weather conditions, unusual events (well tampering), field measurements, etc.

In addition to the field notebooks, a site logbook shall be maintained by the FOL. This log will contain a summary of the day's activities and will reference field notebooks when applicable. Various field reports will also be maintained.

Field reports for this project shall include boring logs, monitoring well installation reports, and quantities used for subcontractual services.

3.1.9 Performance of Field Audits During field activities, a quality assurance audit of procedures will be performed by the QAO as described in the QAPP. The QAO will accompany personnel into the field to verify that the site FSP is being followed. Audit findings will be documented and distributed to project team members and the project file.

3.1.10 Quality Control Samples Quality control (QC) samples generated for laboratory analyses during the NAS Whiting Field RI will include duplicate samples, replicate samples (if requested by Southern Division), spiked samples, trip blanks, field blanks, and equipment blanks. Trip blanks will be provided by the laboratory.

3.1.11 Field Changes and Corrective Action The FOL or his designee is responsible for all site activities. In this role, the FOL may, at times, be required to adjust the site program to accommodate site-specific needs. When such a change is determined to be necessary, written notification of the change will be submitted by the initiator to the TD and Southern Division's EIC, and a copy will be attached to the file copy of the affected document. If unacceptable, the actions during the period of deviation will be evaluated to determine the significance of the departure from established program practices.

Changes made in the field to a site program will be documented on a Field Change Request Form (Figure 3-1). This form will be signed by the initiator and the TD. Field Change Requests will be numbered sequentially, starting with the number 1.

The TD is responsible for the control, tracking, and implementation of the identified site program changes. Completed Field Change Request forms will be distributed to affected parties that will include, at a minimum, Southern Division's EIC and the PM, PrM, TD, QAO, and FOL.

3.1.12 Field Instruments Numerous field monitoring instruments will be used during the field investigation and may include the following:

- temperature probe;
- specific conductance meter;
- pH meter;
- Eh meter;
- photoionization or flame ionization meter;
- radiation meter;
- dual detector, % O_2/ % LEL; and
- water level meter.

Each instrument will be calibrated according to the manufacturer's operating manual prior to each day's use and at the end of each day's use. Calibrations will be documented on the Equipment Calibration Log. During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or failed parts are identified during the daily maintenance check and it is determined that the damage can impact the instrument's performance, the instrument will be removed from service until the identified parts are repaired

QUALITY ASSURANCE PROJECT PLAN
SOUTHERN DIVISION CONTRACT NO. __________
REVISION NO. ________
REVISION DATE ________

ASSIGNMENT NO.	E.C. JORDAN CO.	WORK CHARGE NUMBER	FIELD CHARGE NUMBER

FCR ________

TO ____________________ LOCATION ____________________ DATE ________

DESCRIPTION:

REASON FOR CHANGE:

RECOMMENDED DISPOSITION:

FIELD OPERATIONS LEADER (Signature) DATE

DISPOSITION:

TECHNICAL DIRECTOR DATE

DISTRIBUTION: Program Manager
Technical Director
Southern Division EIC
Project Manager
Quality Assurance Manager
Field Operations Leader

Others as required ______

FIGURE 3-1

FIELD CHANGE REQUEST FORM

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

or replaced. An equivalent piece of equipment will be substituted for the downed instrument to maintain schedule.

<u>3.1.13 Decontamination Procedures</u> Field sampling equipment will be decontaminated using the procedures outlined in Section 6.3 of the QAPP (Appendix B). Each step of the decontamination procedure will be reviewed by field team members during the mobilization phase of the project.

<u>3.1.14 RI Waste Management</u> All potentially hazardous wastes generated during the RI will be placed in Department of Transportation approved 55-gallon drums and stored onsite in a secure area. Wastes that will be handled in this way include:

- nitric acid solution and isopropanol from decontamination,
- disposable protective clothing,
- disposable sampling equipment, and
- well purge water.

NAS Whiting Field, through the Defense Reutilization and Marketing Office, will be responsible for the removal and disposal of these drums.

All non-contaminated waste materials generated onsite will be collected and bagged for appropriate disposal as normal domestic waste. Soil cuttings from the drilling program will be buried onsite.

<u>3.2 RI FIELD INVESTIGATION OVERVIEW</u>. Six major tasks have been delineated for the RI field investigation (see Table 3-1). The tasks include Preliminary Activities, the Hydrogeologic Investigation, the Surface Water and Sediment Investigation, the Source Area Investigation, the Additional Sources Investigation, and the Potential Receptors Survey.

The RI field investigation will be conducted in two phases. The intent of Phase I activities will be to verify the existence or absence of groundwater contamination emanating from the 13 sites and to develop a comprehensive understanding of the sand and gravel aquifer underlying NAS Whiting Field.

Based upon the results of the Phase I investigation, Phase II operations will be undertaken to provide data on the source and extent of contamination, contaminant transport mechanisms, and potential receptors. The primary tasks to be undertaken during Phase II include the installation of downgradient monitoring wells, groundwater sampling and analysis, known source area and groundwater contaminant plume delineation and characterization, identifying additional source areas impacting the activities production wells, and identifying potential receptors.

The discussion that follows presents the tasks to be undertaken to complete the Phase I RI field investigation. Although Phase II activities are anticipated, the exact number of explorations and their placement will not be known until after Phase I activities are completed and the data analyzed. Hence, the discussion of these tasks will be limited to current knowledge and the general technical program necessary to complete the tasks.

3.3 PRELIMINARY ACTIVITIES. Preliminary activities associated with the RI site investigation at NAS Whiting Field include securing subcontractors to perform the PCPT/*in-situ* groundwater sampling program, monitoring well installations, and laboratory analysis; arranging for the acquisition of necessary permits and other authorizations; conducting a reconnaissance of the sites to determine logistics (i.e., location of exploration, decontamination stations, etc.); and mobilization of equipment and supplies to NAS Whiting Field.

The mobilization subtask consists of field personnel orientation and equipment mobilization and will be performed at the initiation of the subsurface investigation and sampling program. A field team orientation meeting will be held to familiarize personnel with site history, health and safety requirements, and field procedures.

Equipment mobilization will include the procurement of rentals (if appropriate) and set-up of the following items:

- field office,
- field GC,
- sampling equipment,
- health and safety equipment,
- decontamination materials, and
- utility hook-ups, if necessary.

3.4 HYDROGEOLOGIC INVESTIGATION. The hydrogeologic investigation at the 13 sites located at NAS Whiting Field is composed of seven tasks. These tasks include:

1. Borehole Geophysics,
2. Monitoring Well/Piezometer Installation,
3. PCPT/*In-Situ* Groundwater Sampling and Analysis,
4. Well Measuring Point Survey,
5. Potentiometric Surface Survey,
6. Aquifer Hydraulic Properties Investigation, and
7. Contaminant Plume Delineation.

Tasks 1 through 6 are structured in a phased approach to provide a clearer definition of groundwater conditions underlying the various sites at NAS Whiting Field. Information derived from these six tasks will be used either to provide sufficient data to propose a no further action (for groundwater) remedial alternative at sites where groundwater contamination is not detected or provide sufficient information to optimize explorations to delineate the nature and extent of groundwater contamination. Figure 3-2 presents the decision mechanism for defining the outcome of the Phase I hydrogeologic investigation.

The underlying premise governing the sequence of events for the hydrogeological investigation is the potential that an extensive upper aquifer zone semiconfining to confining clay layer underlies NAS Whiting Field. Boring logs generated by Geraghty & Miller (1986) suggest the existence of such a clay layer at approximately 90 to 110 feet BLS throughout most of the air station.

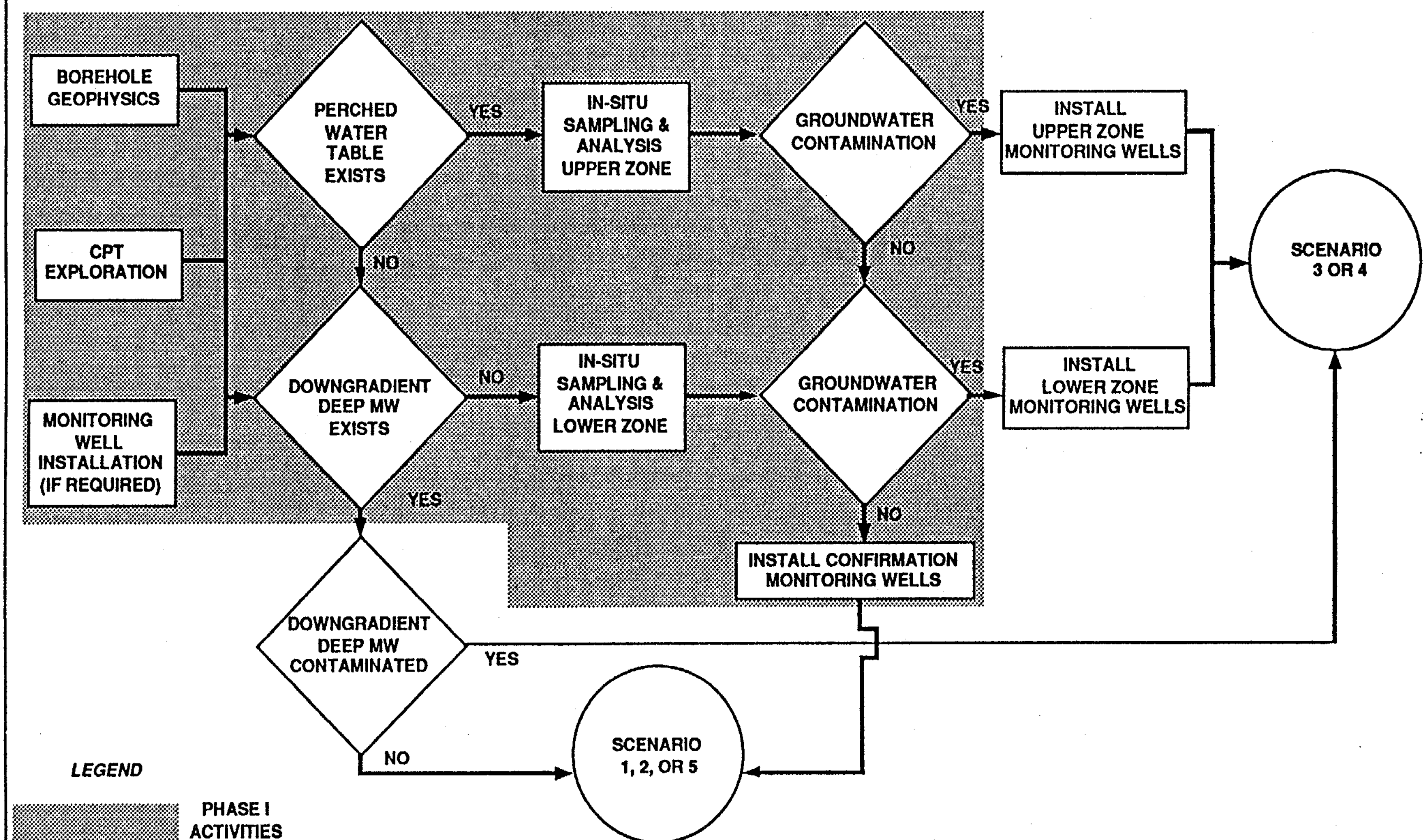


FIGURE 3-2

HYDROGEOLOGIC INVESTIGATION FLOW CHART

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

It is anticipated that if such a clay layer exists the vertical migration of contaminants to the lower zone within the sand and gravel aquifer will be retarded. Analytical results from production wells W-W3 and W-S2 indicate groundwater contamination in the lower aquifer zone. However, the potential exists that the highest concentration of contaminants may exist in the upper aquifer zone (i.e., above the upper clay layer) or within the upper clay. As such, it would continue to act as a source of contamination to the lower aquifer zone.

The initial activities to be undertaken in the hydrogeologic investigation are designed to ascertain both the presence or absence of the upper clay layer, and if present, the presence or absence of contamination in the upper aquifer zone within the sand and gravel aquifer. As such, existing monitoring wells are scheduled for downhole geophysical logging to refine the understanding of the stratigraphy underlying the sites. Subsequent to logging of the existing wells, six additional monitoring wells and two piezometers will be installed at five site groupings. Initially these wells will be used to define groundwater flow direction in the vicinity of the site groupings to aid in subsequent exploration programs.

Based upon the ascertainment of the depth to any existing upper aquifer zone clay layer or lens and a clear definition of flow direction at each site grouping, a piezocone penetration test (PCPT) exploration will be undertaken at each site. Concomitant with this will be groundwater sampling using a Bengt-Arne Torstensson (BAT) System and the subsequent analysis for volatile organic compounds and metals to ascertain if contamination of groundwater has taken place.

The following sections discuss, in more detail, the activities to be undertaken during the hydrogeologic investigation.

3.4.1 Borehole Geophysics Gamma and induction logging will be conducted in the 18 existing monitoring wells and three production wells (if accessible) at NAS Whiting Field. Geophysical logs will be used as a qualitative guide for lithologic correlation to govern the additional subsurface explorations. Specifically, the depth to clay layers or lenses will be initially defined and correlated to the PCPT exploration logs and boring logs. Specific details on downhole geophysical logging procedures are presented in Appendix C of this volume.

3.4.2 Monitoring Well/Piezometer Installation Monitoring wells are scheduled for installation at five sites or site groupings (Table 3-2) around NAS Whiting Field. Due to the position of existing monitoring wells in these areas, groundwater flow direction and hydraulic gradients are not well defined. Prior to the installation of downgradient explorations at specific sites, it will be necessary to describe flow direction for optimal placement. This program is intended to achieve this goal.

Due to the depths involved for well placement, boreholes for monitoring well installation will be advanced using mud rotary techniques. Standard penetration tests will be conducted at 5-foot intervals and at stratigraphic unit changes throughout each overburden boring. Overburden samples collected with the split-spoon sampler will be logged by the onsite field geologist. Boring logs will

TABLE 3-2
MONITORING WELL/PIEZOMETER PLACEMENT
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

SITE NUMBER(S)	WELL NUMBER	TOTAL DEPTH (BLS) IN FEET	SCREEN INTERVAL (BLS) IN FEET	CLAY INTERNAL (BLS) IN FEET*
MONITORING WELLS				
3	WHF-3-3	150	145 - 150	110 - 130
9/10	WHF-9-2	120	115 - 120	75 - 90
11/14	WHF-11-2	150	145 - 150	90 - 125
15/16	WHF-15-2	75	70 - 75	40 - 65
5	WHF-5-OW-1	175	170 - 175	150 - 170
	WHF-5-OW-2	150	145 - 150	
PIEZOMETERS				
5	WHF-5-PZ-1	155		
	WHF-5-PZ-2	165		

* Geraghty & Miller (1986)

NOTE: For monitoring wells in high traffic areas, protective pad and posts will be installed.
BLS - below land surface

be used to ground truth the results of the PCPT and downhole geophysical logging exploration programs.

If an upper aquifer zone, confining or semi-confining clay layer is confirmed to be present, Shelby tube samples will be collected within this upper clay layer. Shelby tube samples will be collected in accordance with American Society for Testing and Materials (ASTM) Designation: D1587-83, Standard Practice for Thin-Walled Tube Sampling of Soils, as outlined in Section 6.6.2 in the QAPP (Appendix B). Shelby tube samples shall be sent to the geotechnical laboratory for the measurement of hydraulic conductivity using a constant head procedure (USEPA Method 9100) for undisturbed samples.

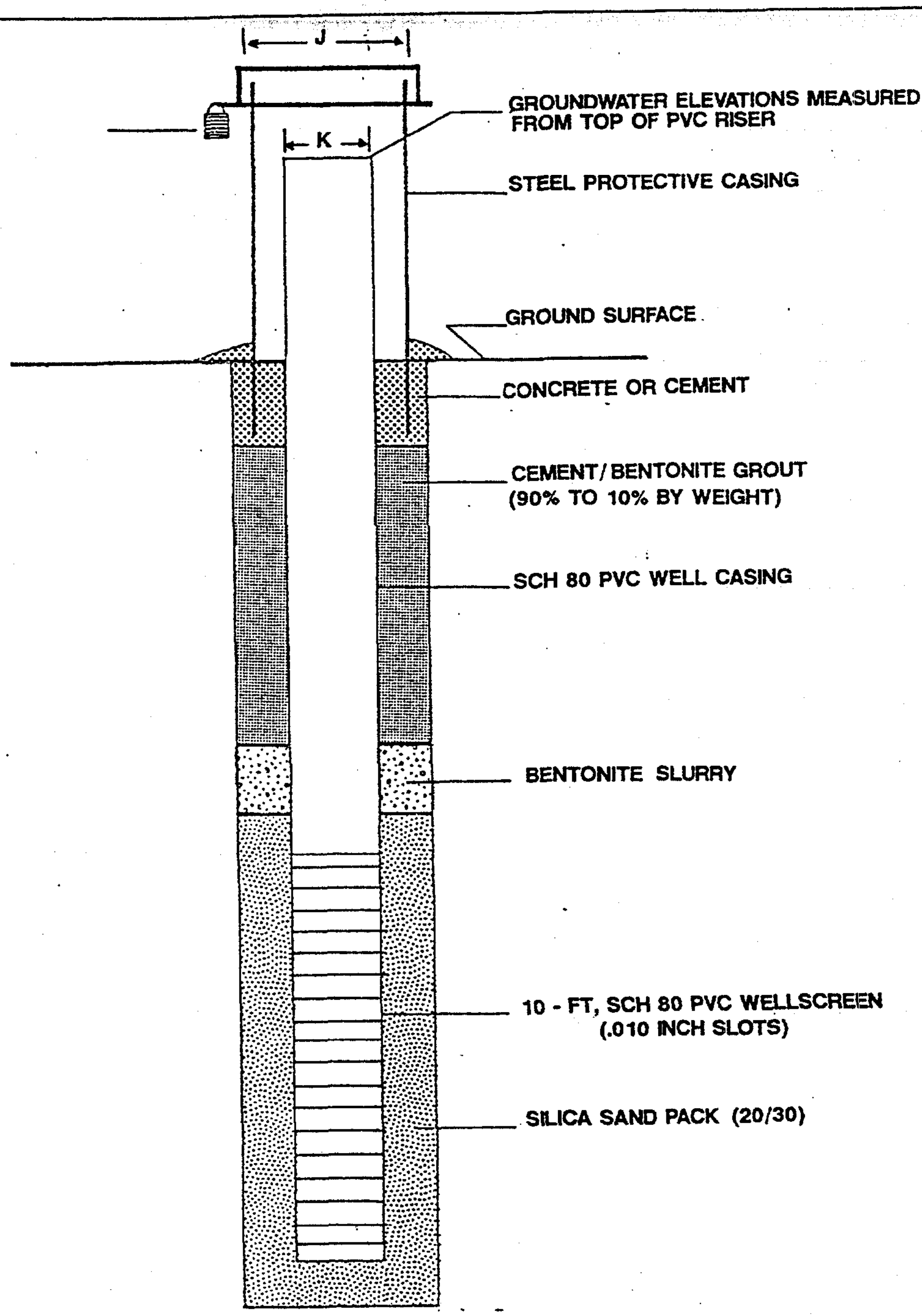
Background monitoring well screen placement will be within the screened interval of existing monitoring wells. Specific well screen placement will be determined by geologic conditions encountered.

Figures 3-3A and 3-3B present the typical monitoring well installation details for NAS Whiting Field. The single-cased well (see Figure 3-3A) will be installed at site or site groupings where a confining or semi-confining unit does not exist. Wells will be constructed of 4-inch inside diameter (ID), flush-threaded, Schedule 80 PVC with a 10-foot section of machine-slotted polyvinyl chloride (PVC) well screen (No. 10 slot size). The annulus around the screen will be sand packed using 20/30 grade silica sand. The sand pack will be tremied into the annular space to a maximum of 2 feet above the top of the screen. A 2-foot bentonite slurry seal will be tremied above the sand pack. A mixture of portland cement and bentonite will be tremied into the annular space above the bentonite seal to the surface to eliminate any vertical conduits created by the drilling process. Material and construction of single-cased monitoring wells will conform with Southern Division's Specifications for Groundwater Monitoring Well Installation (3 November 1988) and Chapter 40 A-3, FAC. Regulation of Wells as Enforced by the Northwest Florida Water Management District.

Double-cased wells (see Figure 3-3B) will be installed at sites underlain by a confining to semi-confining clay unit. Construction of double-cased wells will be in accordance with industry standards, Navy guidance, and Chapter 40 A-3, FAC. The installation of a double-cased well shall require the placement of an 8-inch ID (minimum), flush-treaded, Schedule 80 PVC outer casing at least 2 feet into the confining unit. Under no circumstance will the outer casing breach the confining unit. A mixture of portland cement and bentonite shall be tremie grouted in the annular space surrounding the casing.

Within the outer casing a 4-inch ID, flush-threaded, Schedule 80 PVC monitoring well will be installed to the depth required. The well will consist of a 10-foot section of No. 10 machine-slotted screen and riser pipe. The annulus around the well screen will be tremie filled with 20/30 grade silica sand to a maximum of 2 feet above the screen followed by 2 feet of bentonite slurry. A mixture of Portland cement and bentonite shall be tremie grouted into the remaining annular space to the ground surface to prevent leakage across the confining unit.

An aboveground protective steel casing will be installed and cemented into the ground over each well riser. The steel casings will be equipped with locking covers and keyed-alike brass padlocks. A concrete pad will be placed at ground surface around each protective casing to secure the casing and to prevent surface



NOTE:

K = 4" INSIDE DIA. SCH 80 PVC.

J = 6" STEEL PROTECTIVE CASING, WITH LOCKING COVER

NOT TO SCALE

FIGURE 3-3A

MONITORING WELL INSTALLATION DETAIL SINGLE-CASE WELL

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

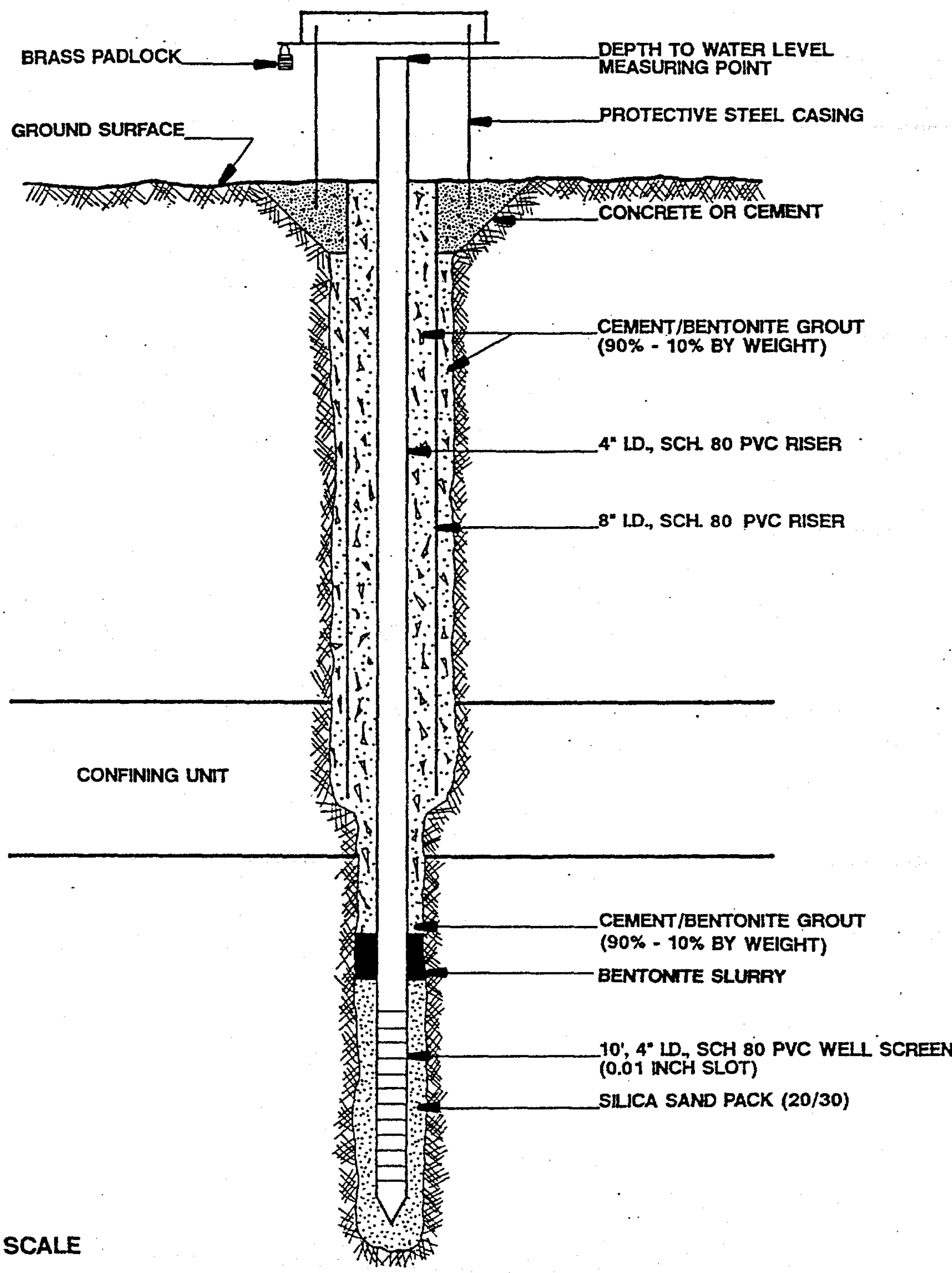


FIGURE 3-3B
MONITORING WELL
INSTALLATION DETAIL
DOUBLE CASED WELL

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

runoff from entering the borehole. The aboveground portions of both the well riser and protective casing will be vented. Wells will be properly identified using Southern Division's identification scheme. In vehicular traffic areas four protective steel posts will be installed around the monitoring well in accordance with Southern Division's specifications. Details on monitoring well protective measures are presented in the Site-Specific Quality Assurance Plan (Appendix C).

Piezometers (Figure 3-4) are slated for installation in the upper clay layer underlying Site 5. One piezometer each will be installed within both the upper and lower portion of the clay. Water level measurements obtained from each piezometer will be used to calculate the vertical hydraulic gradient across the clay layer which will be used to determine if confining conditions exist in the lower aquifer zone. Water table positions will also be monitored during the proposed pumping test (see Section 3.4.5) to aid in the calculation of the vertical hydraulic conductivity in the upper aquifer zone clay layer.

As depicted in Figure 3-2, it is anticipated that certain sites (i.e., sites where initial Phase I RI data indicate that the site can be proposed for either an accelerated operable unit or a no further action or monitoring only record of decision) will have confirmation monitoring wells installed around them at the end of the Phase I RI. Confirmation monitoring wells will be constructed in the manner discussed previously except for sites where a monitoring only record of decision (ROD) will be proposed. In this latter case monitoring wells will be constructed of either Type 316 stainless steel or other materials suitable for the groundwater environment.

<u>3.4.3 PCPT/In-Situ Groundwater Sampling</u> A piezocone penetration test (PCPT) exploration program is scheduled for 12 of the 13 IR Program sites located on NAS Whiting Field. Explorations will be done in accordance with ASTM Designation: D3441-86, <u>Standard Test Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soils</u>.

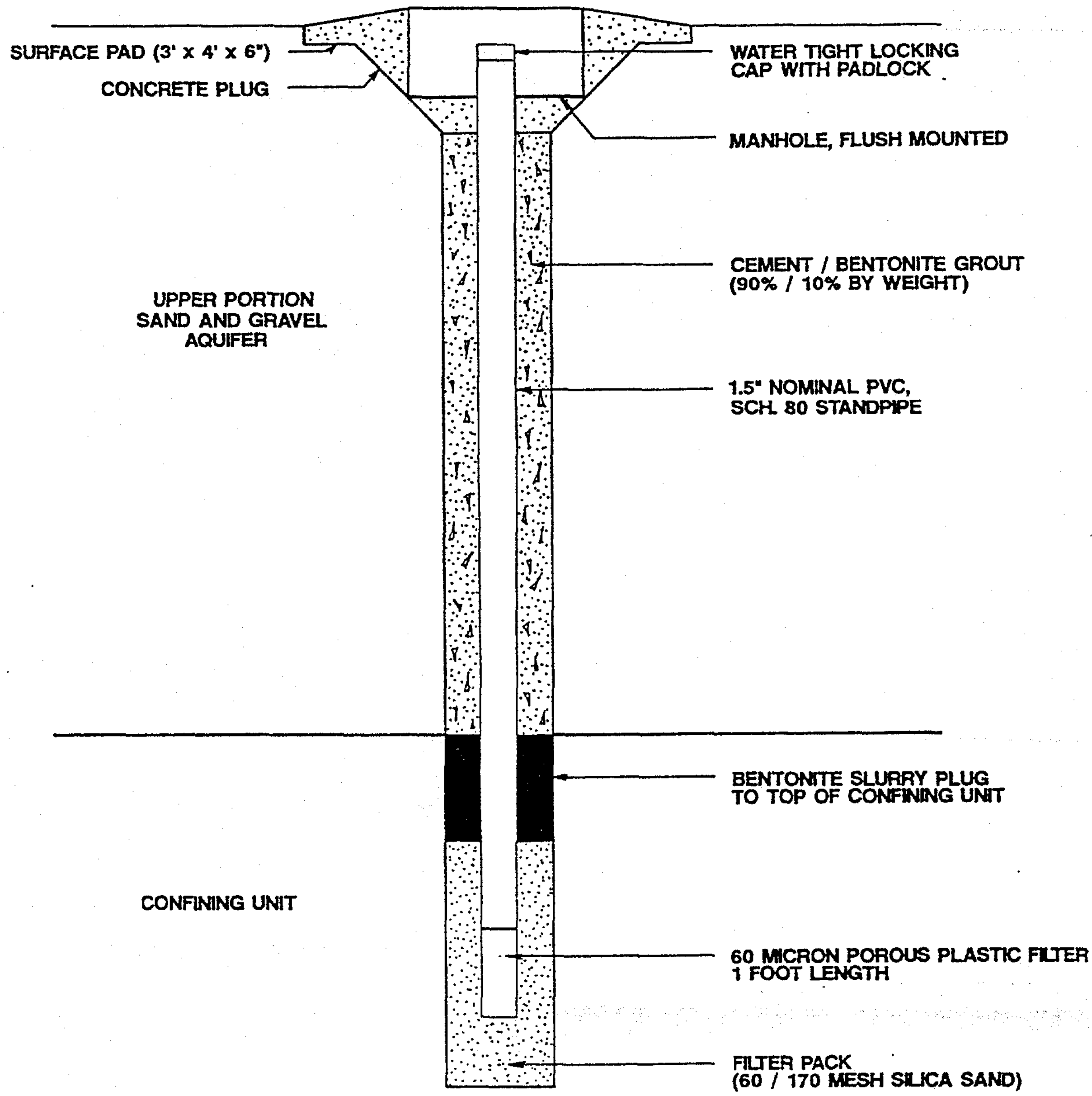
Piezocone soundings at each site will be conducted to a depth corresponding to the lower clay layer (ca. -25 feet NGVD). Measurements of end-bearings resistance, frictional resistance, and pore pressure will be made throughout the sounding. In addition, inclinometer readings shall be made throughout depth to increase the reliability of the exploration, as it provides a record of the verticality of the rods during penetration.

Analog signals from the four sensors will be digitized for data logging. Analysis of digital data will be done in the field through a commercially available data acquisition system with appropriate software supplied by the subcontractor. Graphical and tabular presentation of PCPT data shall include the following:

1) - measured cone resistance, q_c vs. depth
q_c = bearing force/bearing area

- measured sleeve friction stress, f_s vs. depth
f_s = frictional sleeve force/surface area of sleave

- measured pore pressure, u_t vs. depth



NOT TO SCALE

FIGURE 3-4

PIEZOMETER INSTALLATION DETAIL

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

2) - corrected total cone resistance, q_t vs. depth
- corrected total sleeve friction, f_t vs. depth
- measured pore pressure, u_t vs. depth (including equilibrium water pressures, u_o)
- friction ratio, ft/q_t x 100 vs. depth
- differential pore pressure ratio, $(u_t - u_o)/(q_t - u_o)$ vs. depth

Stratigraphic information and pore pressure distribution data shall be used to ascertain the following:

- hydrogeologic setting,
- position of upper clay layers or lenses which may be retarding vertical migration of contaminants,
- position, depth, and thickness of perched groundwater body, and
- groundwater sampling depths for *in-situ* sampling program.

Raw data from at least one PCPT exploration per site grouping will be evaluated by a senior geophysicist using existing boring logs. Results of this analysis will be compared to its corresponding computer generated analysis for verification. This step is intended to assure the quality of information derived from the PCPT explorations. Should questions arise as to the validity of the computer data, raw data from all PCPT explorations will be evaluated by the senior geophysicist.

Upon completion of the PCPT exploration program at each site, groundwater samples will be obtained downgradient of each site utilizing the BAT System. Should data from the PCPT exploration program indicate that a perched groundwater body or upper aquifer zone exists, a groundwater sample shall be obtained from this water bearing zone. In addition, a groundwater sample will be obtained within the lower aquifer zone. Should no confining or semi-confining layer exist, only one sample will be obtained within the lower aquifer zone. Table 3-3 presents a summary of the PCPT/*in-situ* groundwater sampling program for each site. This table assumes that an upper aquifer zone exists and, therefore, presents the maximum number of samples to be obtained.

Groundwater samples collected during the *in-situ* sampling program will be shipped overnight to the analytical laboratory for the analysis of target compound list (TCL) volatile organics and target analyte list (TAL) metals (Table 3-4). In that the *in-situ* sampling program is intended as a screening technique for ascertaining the presence or absence of groundwater contamination, samples will be analyzed in accordance with NEESA data quality Level C QC objectives.

3.4.3.1 Exploration Techniques Due to the depths involved and the potential for the existence of a confining or semi-confining clay layer, the PCPT/*in-situ* sampling exploration program will be conducted in two steps. Initially the piezocone penetrometer test will be conducted to a vertical position just above the upper aquifer zone confining unit. The approximate depth to this unit will be determined from the downhole geophysical logs and boring logs from both new and existing monitoring wells. Should existing logs indicate that no significant confining unit exists, the initial PCPT will be conducted to a depth of approximately 100 feet BLS.

TABLE 3-3
IN-SITU GROUNDWATER SAMPLE IDENTIFICATIONS
RI/FS WORK PLAN
NAS WHITING FIELD

SITE NUMBER	SAMPLE NUMBER	APPROXIMATE DEPTH (FEET BLS)	PCPT DEPTH (FEET BLS)
1	WHF-1-WP-01-01	85	170
	WHF-1-WP-01-02	170	
3	WHF-3-WP-01-01	110	200
	WHF-3-WP-01-02	200	
	WHF-3-WP-02-01	110	200
	WHF-3-WP-02-02	200	
9	WHF-9-WP-01-01	75	150
10	WHF-10-WP-01-01	75	150
	WHF-10-WP-02-01	75	150
	WHF-10-WP-02-02	150	
11	WHF-11-WP-01-01	50	150
12	WHF-12-WP-01-01	90	
	WHF-12-WP-01-02	160	160
13	WHF-13-WP-01-01	80	130
	WHF-13-WP-02-01	80	130
	WHF-13-WP-02-02	130	
14	WHF-14-WP-01-01	9	160
	WHF-14-WP-01-02	160	
15	WHF-15-WP-01-01	?	100
	WHF-15-WP-01-02	100	
	WHF-15-WP-02-01	?	100
	WHF-15-WP-02-02	100	
16	WHF-16-WP-01-01	?	80
	WHF-16-WP-01-02	80	
	WHF-16-WP-02-01	?	80
	WHF-16-WP-02-02	80	
17	WHF-17-WP-01-01	?	200
18	WHF-18-WP-01-01	100	200
	WHF-18-WP-01-02	200	

Total PCPT Exploration: 2,570 feet
Total *In-Situ* Groundwater Samples: 29

TABLE 3-4
TARGET COMPOUND LIST
RI/FS WORK PLAN
NAS WHITING FIELD

VOLATILE ORGANICS

VOLATILES	CAS NUMBER
1. Chloromethane	74-87-3
2. Bromomethane	74-83-9
3. Vinyl Chloride	75-01-4
4. Chloroethane	75-00-3
5. Methylene Chloride	75-09-2
6. Acetone	67-64-1
7. Carbon Disulfide	75-15-0
8. 1,1-Dichloroethene	75-35-4
9. 1,1-Dichloroethane	75-34-3
10. 1,2-Dichloroethene (total)	540-59-0
11. Chloroform	67-66-3
12. 1,2-Dichloroethane	107-06-2
13. 2-Butanone	78-93-3
14. 1,1,1-Trichloroethane	71-55-6
15. Carbon Tetrachloride	56-23-5
16. Vinyl Acetate	108-05-4
17. Bromodichloromethane	75-27-4
18. 1,2-Dichloropropane	78-87-5
19. cis-1,3-Dichloropropene	10061-01-5
20. Trichloroethene	79-01-6
21. Dibromochloromethane	124-48-1
22. 1,1,2-Trichloroethane	79-00-5
23. Benzene	71-43-2
24. trans-1,3-Dichloropropene	10061-02-6
25. Bromoform	75-25-2
26. 4-Methyl-2-pentanone	108-10-1
27. 2-Hexanone	591-78-6
28. Tetrachloroethene	127-18-4
29. Toluene	108-88-3
30. 1,1,2,2-Tetrachloroethane	76-34-5
31. Chlorobenzene	108-90-7
32. Ethylbenzene	100-41-4
33. Styrene	100-42-5
34. Xylenes (total)	1330-20-7

TABLE 3-4 (Cont.)
TARGET COMPOUND LIST
RI/FS WORK PLAN
NAS WHITING FIELD

SEMIVOLATILE ORGANICS

SEMIVOLATILES	CAS NUMBER
35. Phenol	108-95-2
36. bis (2-Chloroethyl) ether	111-44-4
37. 2-Chlorophenol	95-57-8
38. 1,3-Dichlorobenzene	541-73-1
39. 1,4-Dichlorobenzene	106-46-7
40. Benzyl alcohol	100-51-6
41. 1,2-Dichlorobenzene	95-50-1
42. 2-Methylphenol	95-48-7
43. bis (2-Chloroisopropyl) ether	108-60-1
44. 4-Methylphenol	106-44-5
45. N-Nitroso-di-n-dipropylamine	621-64-7
46. Hexachloroethane	67-72-1
47. Nitrobenzene	98-95-3
48. Isophorone	78-59-1
49. 2-Nitrophenol	88-75-5
50. 2,4-Dimethylphenol	105-67-9
51. Benzoic acid	65-85-0
52. bis (2-Chloroethoxy) methane	111-91-1
54. 1,2,4-Trichlorobenzene	120-82-1
55. Naphthalene	91-20-3
56. 4-Chloraniline	106-47-8
57. Hexachlorobutadiene	87-68-3
58. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7
59. 2-Methylnaphthalene	91-57-6
60. Hexachlorocyclopentadiene	77-47-4
61. 2,4,6-Trichlorophenol	88-06-2
62. 2,4,5-Trichlorophenol	95-95-4
63. 2-Chloronaphthalene	91-58-7
64. 2-Nitroaniline	88-74-4
65. Dimethylphthalate	131-11-3
66. Acenaphthylene	208-96-8
67. 2,6-Dinitrotoluene	606-20-2
68. 3-Nitroaniline	99-09-2
69. Acenaphthene	83-32-9
70. 2,4-Dinitrophenol	51-28-5
71. 4-Nitrophenol	100-02-7
72. Dibenzofuran	132-64-9
73. 2,4-Dinitrotoluene	121-14-2
74. Diethylphthalate	84-66-2
75. 4-Chlorophenyl-phenyl ether	7005-72-3
76. Fluorene	86-73-7
77. 4-Nitroaniline	100-01-6
78. 4,6-Dinitro-2-methylphenol	534-52-1
79. N-nitrosodiphenylamine	86-30-6
80. 4-Bromophenyl-phenylether	101-55-3
81. Hexachlorobenzene	118-74-1

TABLE 3-4 (Cont.)
TARGET COMPOUND LIST
RI/FS WORK PLAN
NAS WHITING FIELD

SEMIVOLATILE ORGANICS

SEMIVOLATILES	CAS NUMBER
82. Pentachlorophenol	87-86-5
83. Phenanthrene	85-01-8
84. Anthracene	120-12-7
85. Di-n-butylphthalate	84-74-2
86. Fluoranthene	206-44-0
87. Pyrene	129-00-0
88. Butylbenzylphthalate	85-68-7
89. 3,3'-Dichlorobenzidine	91-94-1
90. Benzo(a)anthracene	56-55-3
91. Chrysene	218-01-9
92. bis (2-Ethylhexyl)phthalate	117-81-7
93. Di-n-octylphthalate	117-84-0
94. Benzo(b)fluoranthene	205-99-2
95. Benzo(k)fluoranthene	207-08-9
96. Benzo(a)pyrene	50-32-8
97. Indeno(1,2,3-cd)pyrene	193-39-5
98. Bebenz(a,h)anthracene	53-70-3
99. Benzo(g,h,i)perylene	191-24-2

TABLE 3-4 (Cont.)
TARGET COMPOUND LIST
RI/FS WORK PLAN
NAS WHITING FIELD

PESTICIDES/PCBs

PESTICIDES/PCBs	CAS NUMBER
100. alpha-BHC	319-84-6
101. beta-BHC	319-85-7
102. delta-BHC	319-86-8
103. gamma-BHC (Lindane)	58-89-9
104. Heptachlor	76-44-8
105. Aldrin	309-00-2
106. Heptachlor epoxide	1024-57-3
107. Endsulfan I	959-98-8
108. Dieldrin	60-57-1
109. 4,4'-DDE	72-55-9
110. Endrin	72-20-8
111. Endosulfan II	33213-65-9
112. 4,4'-DDD	72-54-8
113. Endosulfan sulfate	1031-07-8
114. 4,4'-DDT	50-29-3
115. Methoxychlor	72-43-5
116. Endrin ketone	53494-70-5
117. alpha-Chlordane	5103-71-9
118. gamma-Chlordane	5103-74-2
119. Toxaphene	8001-35-2
120. Aroclor-1016	12674-11-2
121. Aroclor-1221	11104-28-2
122. Aroclor-1232	11141-16-5
123. Aroclor-1242	53469-21-9
124. Aroclor-1248	12672-29-6
125. Aroclor-1254	11097-69-1
126. Aroclor-1260	11096-82-5

TABLE 3-4 (Cont.)
TARGET COMPOUND LIST
RI/FS WORK PLAN
NAS WHITING FIELD

INORGANIC TARGET ANALYTE LIST (TAL)

Analyte
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc
Cyanide

If scheduled, a BAT System groundwater sample will be obtained at this depth. Upon extraction of the BAT sample, a pilot hole will be augured to the desired depth and a 3-inch ID, PVC casing will be installed. If a confining unit exists, the casing shall be installed within the clay to prevent cross-contamination of the aquifer units. Exact depths for PVC casing installation shall be determined from conditions encountered in the field.

Step two in this process shall consist of completing the PCPT exploration to final depth and collecting the lower aquifer zone *in-situ* groundwater samples. After completion of the cased pilot hole, the piezocone shall be inserted to the bottom of the casing. The casing will be backfilled with silica sand to prevent rod deformation and then the PCPT shall be conducted to completion depth. Upon extraction of the piezocone penetrometer, the BAT System shall be driven to the desired depth in the lower aquifer zone and the sample collected.

Upon completion of the exploration, the cased pilot hole shall be reamed out and the borehole tremie grouted to the surface.

3.4.4 Well Elevation/Location Survey At the end of the installation of Phase I monitoring wells at each site grouping, an initial elevation survey will be conducted. New monitoring well measuring point elevations will be tied in with existing measurements within site groupings to assess groundwater flow direction. Details for undertaking the initial measuring point elevation survey are presented in the Site-Specific Quality Assurance Plan Addendum (Appendix C).

Subsequent to Phase II monitoring well installation, a well elevation/location survey will be conducted by a registered land surveyor. The spatial position, elevation of well measuring point, and ground elevation will be surveyed for each monitoring well, observation well, and piezometer installed at NAS Whiting Field. Spatial coordinates for wells and piezometers will be referenced to NAS Whiting Field grid coordinate system. All elevations will be based on NGVD of 1929.

Third order accuracy will be required for the survey. Horizontal locations will be located to an accuracy of 0.1 feet and elevations will be surveyed to an accuracy of 0.01 feet.

3.4.5 Aquifer Hydraulic Properties In order to characterize the hydraulic properties of the sand and gravel aquifer, both a pumping test and slug tests of individual wells will be undertaken.

A 14-day pumping test is scheduled at NAS Whiting Field to ascertain the hydraulic properties in both the upper and lower zones within the sand and gravel aquifer. Production well W-S2 is to be used as the pumping well. Prior to the pumping test, production wells W-S2 and W-W3 will be off line for 4 days to allow for recovery of the potentiometric surface in the vicinity of W-S2.

The pumping test at production well W-S2 will be run in conjunction with the Phase I source area investigation (see Section 3.7) also slated from this well. As such, the 14-day period for pumping will assure that sufficient time is available to stabilize contaminant migration to the production well and to collect the eight *in-situ* groundwater samples. The off/on time periods for pumping also parallels the typical operation period for production well W-S2, i.e., 10 days on and 5 days off line.

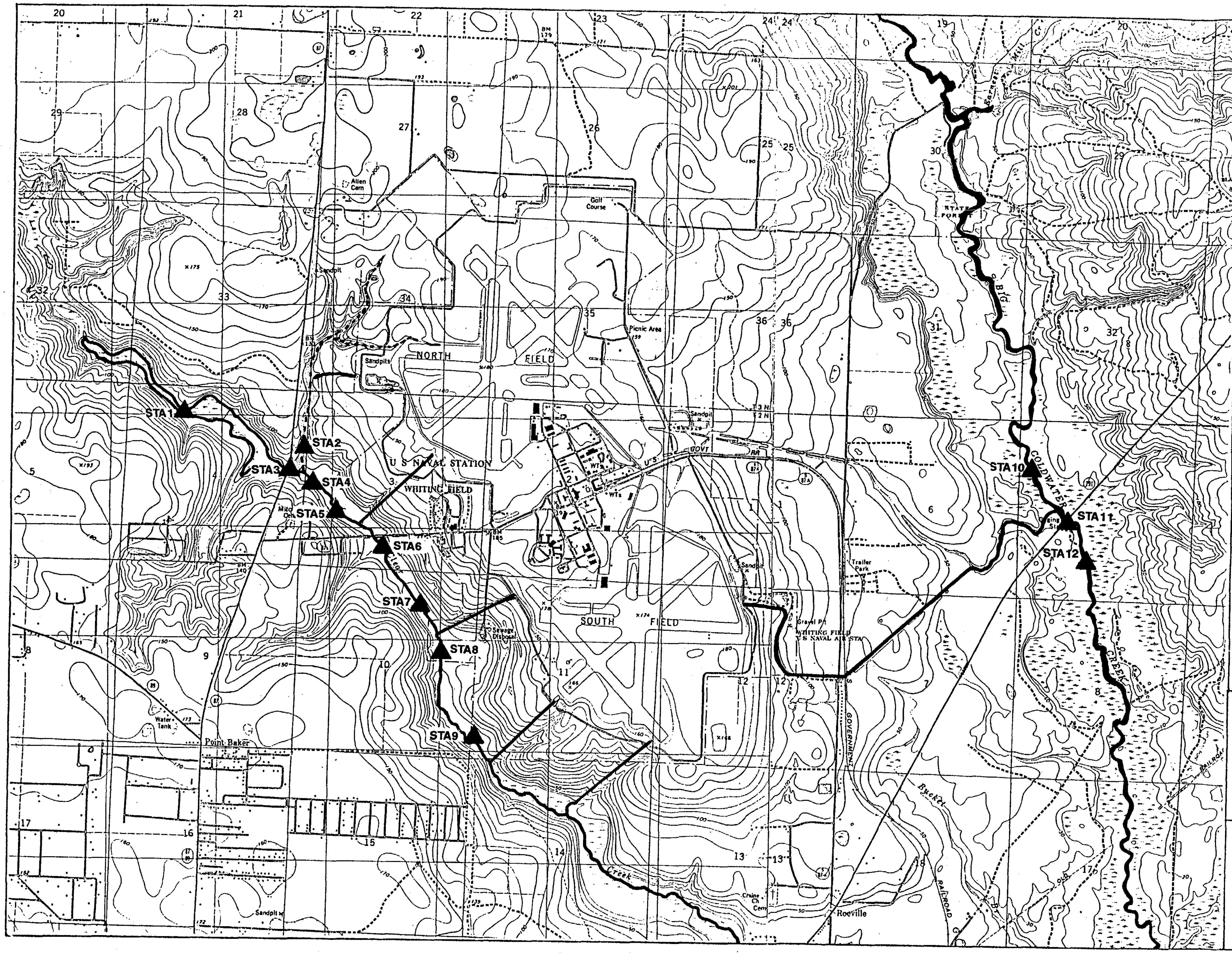
Wells to be monitored during the pumping test shall include monitoring well WHF-5-1, observation wells WHF-5-OW-1 and WHF-OW-2, and piezometers WHF-5-PZ-1 and WHF-5-PZ-2. The approximate locations of the wells and piezometers to be monitored during the pumping test are presented in Figure 3-5, Appendix A. During the pumping test, the new monitoring wells and piezometers will be temporarily equipped with individual pressure transducers coupled to an eight-channel data logger. Potentiometric surface measurements from monitoring well WHF-5-1 shall be obtained manually using an electric tape. In addition, production well discharge will be monitored with the existing orifice weir installed in-line on the production well discharge pipe. Details on undertaking the pumping test are presented in the Site-Specific Quality Assurance Plan Addendum (Appendix C).

Single-hole permeability tests will be performed on each existing and new monitoring well. Both rising and falling head slug-tests will be performed in each individual well except for wells which are screened across the water table. In this case, only rising head tests will be performed. Data will be analyzed by either the method of Cooper et al. (1967) for unconfined conditions or the method of Bouwer and Rice (1976) for unconfined conditions.

Calculated values of hydraulic conductivity (K) will be evaluated by means of a two-way analysis of variance to determine if, (a) a significant difference in K exists in the sand and gravel aquifer across NAS Whiting Field, and (b) a significant difference in K exists between the upper and lower zones of the sand and gravel aquifer. Comparisons shall be made at the 95 percent significance level. Should significant differences exist, a Tukey's test will be run to test for significant differences between individual pairs of sample means.

3.5 SURFACE WATER AND SEDIMENT SAMPLING. In that Clear Creek and Big Coldwater Creek are the primary receiving water bodies for both groundwater and overland flow, 12 sampling stations have been established to collected samples for laboratory analysis. The intent of the program is to evaluate whether the two creeks have been impacted by past activities at NAS Whiting Field, and if not, their current condition. Data derived from this subtask will be used in the ecological baseline risk assessment. Assessments will be made with regard to both current condition and anticipated future conditions during remedial alternatives evaluation.

3.5.1 Number and Location of Sampling Stations Twelve surface water and sediment samples will be collected from locations along Clear Creek and Big Coldwater Creek, as shown in Figure 3-6. These locations are approximate and may be relocated based on actual site conditions. All samples will be sent to the laboratory for analyses of the constituents listed in Section 3.9 of this SAP.



LEGEND

STA1 ▲ AQUATIC SAMPLING STATION

SCALE IN FEET

0 3000 6000

SOURCE:
USGS QUADRANGLE MILTON NORTH, FLORIDA
PHOTOREVISED 1987
AND USGS QUADRANGLE HAROLD, FLORIDA 1973.

FIGURE 3-6

SURFACE WATER/SEDIMENT/BIOTA SAMPLING STATIONS

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

00182B04Z

3.5.2 Sampling Procedures All samples will be collected in accordance with procedures discussed in Sections 6.7.3 and 6.6.5 of the QAPP. Surface water samples will be collected by dipping the sample container directly into the water. If the water is not deep enough to permit the use of this method, a glass or stainless steel beaker will be used to transfer the sample into the container. Sediment samples will be collected using a stainless steel scoop, mixed in a glass or stainless steel pan, and placed into the sample container. Volatile Organic Analytes (VOA) samples will be removed from the stream and placed directly into the sample container without mixing.

3.5.3 Drainage Ditch Sampling Due to the potential for the erosional process to act as a transport mechanism of contaminants to Clear and Big Coldwater Creeks, drainage ditch "Y" and old drainage ditch "A" are scheduled for sediment sampling (see Figure 1-3, Appendix A). Sediment samples will be obtained from the 0.5 to 1.0-foot depth interval within each ditch. Samples will be shipped to the laboratory for the analysis of TCL constituents.

3.6 SOURCE AREA INVESTIGATIONS. Site 6, the South Transformer Oil Disposal Area, is slated for surface soil sampling and analysis. Although a soil sampling program was conducted by Geraghty & Miller (1986) during the Verification Study, additional samples will be collected in areas not previously sampled. Soil samples will be collected from the 0.0 to 0.5-foot depth interval for the analysis of PCBs. Section 3.9.3 presents the exploration program for Site 6.

Site 12, the Tetraethyl Lead Disposal Area, is slated for surface soil sampling and analysis. Three soil samples will be obtained from each of the two mounds. Samples will be shipped to the laboratory for the analysis of total lead and hazardous waste characteristics.

Due to the presence of Boy Scouts of America activities in the vicinity of Sites 15 and 16, surface soils at each landfill will be sampled. At each landfill three randomly located surface soil samples (0.0 to 0.5-foot interval) will be collected for shipment to the laboratory. Soil samples will be analyzed for TCL constituents. Samples collected for TCL volatile organics analysis will be collected in 4-inch brass liners and sealed immediately with Teflon end caps.

This initial soil sampling program at Sites 15 and 16 is intended to ascertain if the potential for a risk to human health by dust inhalation, soil ingestion, etc., exists. If data from this program and the groundwater sampling and analysis program indicate contamination in either medium, a more detailed study will be undertaken.

3.7 PRODUCTION WELL SOURCE AREA INVESTIGATION. Production wells W-W3 and W-S2 are known to be contaminated by trichloroethene and benzene, respectively. However, the source areas affecting these wells are not clearly defined and the extent of groundwater contamination has not been delineated. A phased exploration program has been designed to delineate source areas and to ascertain the extent of groundwater contamination associated with them.

In order to decrease the size of the area to be investigated for source area delineation, the first phase of this program is intended to delineate the radial quadrant from which contaminated groundwater is being pulled toward the two production wells. As such, eight to nine *in-situ* groundwater sampling locations have been established around each production well in a radial pattern. Figures 3-5 (Appendix A) and 3-7 (Appendix A) present the approximate location of the eight to nine *in-situ* sampling points.

For both sites an initial PCPT will be conducted to ascertain groundwater sampling locations within both the upper and lower zone of the sand and gravel aquifer. In that low density petroleum hydrocarbons (i.e., benzene) are a concern at production well W-S2, *in-situ* groundwater samples will initially be obtained only within the upper aquifer zone at the eight sampling locations around the well. These samples will be shipped to the laboratory for the analysis of the TCL volatile organics.

Based upon positive analytical results, lower aquifer zone groundwater samples will be collected only at those locations where volatile organics were detected in upper aquifer zone samples. This approach will ascertain the vertical extent of contamination within the quadrant(s) which are contributing to the contamination of the production wells. For both sampling events, samples will be collected during operation of the production well.

In that trichloroethene, a dense chlorinated hydrocarbon, has been detected in groundwater pumped from production well W-W3, both upper and lower aquifer zone groundwater samples will be collected at the nine locations identified in Figure 3-7.

Positive laboratory results for an *in-situ* groundwater sample will give an indication of the general direction of the source area. This will aid in reducing the overall area to be investigated in a follow-up Source Area Identification Program.

<u>3.8 PHASE II RI TASKS</u>. Upon approval of the Phase II RI SAP, field activities will be initiated to complete the remedial investigation at NAS Whiting Field. Tasks slated for the Phase II RI are listed in Figure 3-1 and summarized in the following sections.

<u>3.8.1 Plume Delineation</u> For those sites or site groupings determined during Phase I activities to have impacted groundwater, a Phase II program will be undertaken to define the nature and extent of the contaminant plume. This program will consist of two exploration techniques: installation of downgradient monitoring wells for long-term monitoring of groundwater quality, and *in-situ* groundwater sampling and analysis to define the extent of the contaminant plume.

To delineate the extent of groundwater contamination emanating from a site or site grouping, an *in-situ* groundwater sampling and analysis program will be undertaken. The intent of this program is to define the vertical and horizontal extent of the contaminant plume. Analysis of groundwater samples will be conducted using a field gas chromatograph. Indicator parameters to be analyzed shall be defined by their presence in samples collected during the initial Phase I *in-situ* groundwater sampling episode (i.e., any of the TCL volatile organics), historical groundwater quality data, and suspected wastes disposed at the site. Knowledge of the contaminant extent will be used to calculate volumes of contaminated groundwater and to properly place permanent monitoring wells.

Based upon the results of the PCPT exploration program and analytical results for the *in-situ* groundwater samples, monitoring wells will be installed downgradient of those sites where groundwater contamination is present. The installation of both upper zone and lower zone monitoring wells are anticipated at this time. The installation of downgradient monitoring wells will result in permanent monitoring stations which will be used to monitor future remedial efforts or monitor contaminant migration.

Boreholes for downgradient monitoring wells will be advanced using mud-rotary techniques. Standard penetration tests will be conducted at 5-foot intervals and at changes in stratigraphy throughout each overburden boring. Split-spoon samples will be logged, placed in 8-ounce driller's jars, and archived for future reference. Headspace readings will be conducted on each driller's jar containing a saturated overburden sample using an organic vapor analyzer to ascertain contaminated water bearing zones.

Monitoring well screen placement and length will be defined based upon the results of the PCPT exploration program, the *in-situ* groundwater sampling and analysis program, and actual field conditions encountered during drilling. Initially, 5-foot sections of slotted screen are proposed for placement just above the upper or lower clay layer.

Modification of this approach will take place if free petroleum product is anticipated to be present in the upper aquifer zone or if a contaminated zone is encountered (as suggested by headspace measurements) above the lower clay.

At sites where floating free product is anticipated, a 10-foot section of screen will be installed. The screen shall be installed such that approximately 6 feet of screen shall extend below the water table. Candidate sites for screen placement across the water table will include those sites where free product was noted during split-spoon sampling or where the analysis of *in-situ* groundwater samples indicate petroleum related contamination (i.e., excessive levels of benzene, ethylbenzene, toluene, total xylenes, etc.).

In borings where headspace measurements indicate contamination above the lower clay layer, monitoring wells will be screened across the zone of contamination. Screen length shall be sized according to the thickness of the contaminated zone by 2.5-foot increments. Maximum length of screen will not exceed 10 feet in these wells.

Monitoring wells to be used for long-term monitoring or where conditions warrent it will be constructed of 4-inch ID, Type 316 stainless steel, with 0.010-inch wire-wrapped well screens. Well screen length will vary due to geologic and hydrogeologic conditions found in each boring, but will not exceed 10 feet in length. The screen will be surrounded with a sandpack consisting of 20/30 mesh silica sand placed by a tremie pipe to a maximum depth of 2 feet above the screen. A 2-foot bentonite slurry plug will then be tremied on top of the sand pack. The remainder of the boring annulus will be backfilled, using a tremie pipe, with a cement/bentonite mixture to within 2 feet of the surface. A protective casing with locking cover (10-inch ID and 6 feet in length) will be placed over the top of the well. Each well and protective casing will extend approximately 3 feet above the ground surface and will be cemented into place. All well construction data will be recorded on well construction sheets. Each monitoring well will be developed after installation. The specific method selected will depend upon the final depth of well, depth to water, aquifer permeability, and parameters selected for analysis. Methods of development available will include: bailing, pumping, or surge blocks.

Well development will take place only after a minimum of 8 hours has elapsed since well completion. Monitoring wells will continue to be developed until a turbidity-free discharge is achieved (i.e., groundwater sample turbidity less than 5 nephelometric turbidity units). However, if this condition cannot be achieved, another well development technique which is less traumatic (e.g., bailing) will be implemented.

Should adequate well development not be achievable due to lithological considerations, recommendations will be made as to how to minimize well trauma during purging in order to obtain a representative sample.

As described in Section 3.4.2 of this SAP, installation methods for both single-cased and double-cased monitoring wells will be followed.

<u>3.8.2 Source Area Delineation</u> For those sites determined during the hydrogeologic investigation to be potentially contributing to groundwater contamination, a detailed source area investigation will be undertaken. The intent of this program will be to determine the types of contaminants present and the lateral and vertical extent of the source area.

At non-landfill source areas, a grid system will be established to define soil boring and sampling locations. The size of the grid will be a direct function of the source area size. Soil samples will be obtained across the grid at a depth corresponding to native soil and at the land surface. The analytical program will be dependent upon types of hazardous waste disposed of at the particular sites. Sites which may have received different types of waste or for which information on disposal practices are sparse will be sampled for the analysis of constituents of the TCL (see Table 3-4).

For landfills, the extent of the source area will be determined by the use of surface geophysical techniques e.g., ground penetrating radar. Due to the difficulty and often hazardous conditions associated with drilling through landfills, this exploratory technique is not advisable for characterizing the types of contaminants present. As such, other sampling techniques, e.g., slant boring from landfill edge, sampling seeps, etc., will be proposed if the need arises. At this time no source area investigations are slated except at the four sites discussed previously.

<u>3.8.3 Production Well Source Area Investigation</u> Based upon the results from the quadrant identification program, a coarse sampling grid (i.e., 500 to 1,000 foot grid interval) will be established in the quadrant identified to be contributing to production well contamination. *In-situ* groundwater samples will

be collected at the appropriate depth and analyzed for indicator parameters (i.e., trichloroethene, benzene, etc.) using a field gas chromatograph.

In addition, facility records of past and present activities will be re-evaluated in an attempt to locate potential source areas. It is anticipated that this will further reduce the area to be investigated.

Should additional source areas be identified during this investigation, additional studies will be proposed to investigate the extent of both groundwater contamination and the source area.

<u>3.8.4 Potential Receptors Survey</u> The purpose of this activity is to obtain the information on the ecology of areas and potential human receptors in and around NAS Whiting Field. This information is needed to support the human and ecological risk assessments and for the evaluation of remedial alternatives. Potential points of exposure for environmental receptors include the terrestrial ecosystems in the vicinity of the various sites and the aquatic ecosystems of Clear Creek, Big Coldwater Creek, and the Blackwater River. These ecosystems were described to some extent in the Initial Assessment Study (Envirodyne Engineers, 1985). The biological survey will verify and supplement the ecological information contained in the Envirodyne report.

The biological survey at NAS Whiting Field will consist of two components:

- terrestrial survey and
- aquatic survey.

The objectives of the biological survey are to provide information necessary to:

- identify environmental receptors within the common flora and fauna of the site and surrounding area;
- identify migration pathways for contaminants in site specific food chains and determine the potential for human exposure;
- identify the location of any threatened, endangered or rare species and sensitive environmental areas or cultural habitats near the site;
- assess possible disruptive effects of contaminants on plant and animal population associated with the site;
- complete any necessary wetlands or floodplains assessments; and
- evaluate the potential ecological impacts associated with remedial alternatives.

The components of the biological survey are described in the following subsections. Field and laboratory methods will be based, in part, on EPA/600/3-89/013, <u>Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document</u>. The objectives of the survey will be accomplished by a qualified biologist.

3.8.4.1 Terrestrial Survey The development of the scope of work for the terrestrial survey will be closely coordinated with the NAS Whiting Field's biologist. Existing information on habitats and biota will be considered in the development of a work plan so as not to duplicate effort. Currently it is known that most of the wetlands on NAS Whiting Field have already been mapped; information on bird species in the region has been catalogued by the Audubon Society; and a survey of rare and endangered plant species has been conducted by the National Heritage Society for the activity. Future surveys proposed by NAS Whiting Field include a survey of endangered plants and wildlife and the identification of terrestrial communities.

To ensure an appropriate scope of work for the terrestrial survey is developed, a strategy meeting shall be conducted between biologists from NAS Whiting Field, Southern Division, and the contractor. The intent of this meeting will be to refine the scope of the terrestrial survey to encompass only those tasks necessary to fill data gaps and thus, reduce the chances of duplicating studies.

Should it be required, the first step of the terrestrial survey will be to identify the wetland and upland plant communities present in the vicinity of each site. The contractor will describe the species of aquatic and terrestrial vegetation present or expected at the site. Species of submergent, floating, emergent, shrub, and tree layer vegetation present in wetlands, streams, and other water bodies will be listed. Herbaceous, shrub, and tree layer species will be described for upland areas.

Wetlands will be identified based on national Wetlands Inventory maps (if available), existing activity wetland maps, U.S. Geological Survey (USGS) topographic maps, aerial photographs, and field investigation. Identification of vegetative cover and soil types around the individual sites at NAS Whiting Field will be recorded by the field biologist on a Wetlands Delineation Form (Figure 3-8).

Field biologists will record any observations of terrestrial wildlife species (i.e., birds, mammals, reptiles, and amphibians). However, it is not possible to fully characterize all species of wildlife present without extensive trapping and field collection efforts. Therefore, scientists will identify potential terrestrial receptors based upon the identified habitat types (wetland and upland plant communities) and reports of the habitats and ranges of indigenous terrestrial wildlife.

3.8.4.2 Aquatic Survey Aquatic organisms are more readily collected for identification than terrestrial wildlife. Scientists will collect plankton, aquatic invertebrates, benthic macroinvertebrates, and fish for taxonomic identification in the surface water bodies and wetlands associated with NAS Whiting Field. Sampling equipment will include a plankton tow, an aquatic dip net, an Ekman or Ponar dredge, and a seine. Site-specific characterization is important because aquatic organisms are the most likely receptors of chemical contamination, and extensive ecotoxicity data exist for them.

<u>Quantitative Benthic Sampling</u> Invertebrate samples will be collected qualitatively by use of an aquatic dipnet and dredge if quantitative sampling is not determined to be necessary. This will include collection of only one sample per location.

WETLANDS DELINEATION FORM
(Based on U.S. Army Corps of Engineers DATAFORM1/JUL88)

Routine Page 1

DATE: ____________________ TRANSECT: ______ PLOT: ______

APPLICANT: ____________________ UTM East: __________ Meters

FILE NUMBER: ____________________ UTM North: __________ Meters

PROJECT TITLE: ____

CITY/TOWN: ____________________ STATE: ______ COUNTY: ______

DETERMINATIONS

Prevalence of Hydrophytes? ( ) NO ( ) YES Basis:

____

Hydric Soils Present? ( ) NO ( ) YES Basis:

____

Wetland Hydrology Apparent? ( ) NO ( ) YES Basis:

CONCLUSIONS

Altered? ( ) NO ( ) YES (If yes, see attached form)
(Soils, Plants, Hydrology)

____

Normal Circumstances? ( ) NO ( ) YES Remarks:

____

Wetland? ( ) NO ( ) YES Remarks:

____

COMMENTS

____
____
____
____
____
____

PRINTED NAME
(Persons performing delineation)

FIGURE 3-8
WETLANDS DELINEATION FORM

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

WETLANDS DELINEATION FORM (continued)

Routine Page 2

Transect: _____ Plot: _____

VEGETATION

TREE:

	Species	Status
1.		
2.		
3.		
4.		

LIANA:

	Species	Status
1.		
2.		
3.		
4.		

SAMPLING/SHRUB:

	Species	Status
1.		
2.		
3.		
4.		

SEEDING/HERB:

	Species	Status
1.		
2.		
3.		
4.		

Percent Hydrophytes: ______% Remarks: ______________________________

Depth & Horizon	Munsell Color (wet) Matrix/Mottle	USDA Texture (wet)	Remarks
0 inch			
3 inch			
5 inch			
16 inch			

Series & Phase:

Check: ( )Histosol ( )Histic Epidedon ( )Anaerobio Soil ( )Sulfidic Odor
( )Aquic Mositure Regime ( )Peraquic Moisture Regime ( )On NICHS List
( )Iron Concretions ( )Manganese Concretions
( )Organic Streaking of Subsurface Horizon in Sandy Soil
( )Organic Pan in Sand Soil ( )Organic Layer Over Sandy Soil >3 in.
COROR IMMEDIATELY BELOW THE A-HORIZON OR AT 10 INCHES, WHICHEVER IS LESS:
( )Gleyed ( )Mottled with Matrix Chroma <2 ( )Unxottled with Chroma <1

HYDROLOGY

OBSERVED DATA Check: ( )Saturation in upper 12 inches ( )Inundation
( )Drift Lines ( )Sediment Deposits ( )Enorsuted Detritus
( )Watermarks ( )Drainage Patterns (in low areas)

Depth of STANDING WATER: Depth to SATURATION

RECORDED DATA:

SOURCE: ______________________________ DATED: ______________

FIGURE 3-8(CONT.)
WETLANDS DELINEATION FORM (PAGE 2)

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

In the laboratory the collected organisms will be sorted, identified to the genus level, where possible, and counted. The analysis results will be recorded on biological identification forms (Figure 3-9). After identification the organisms will be retained in labeled vials in 70 percent ethanol.

At each sampling location for benthic invertebrates other data on water quality and bottom composition will be collected. The information will be recorded on a biological sampling data sheet (Figure 3-10).

If chemical contamination of sediments or surface water in Clear Creek and Big Coldwater Creek is determined to exist during the Phase I RI field investigation, then quantitative sampling of the creeks will be implemented during Phase II to assess the extent of impacts. Three replicate benthic samples will be taken with a Petite Ponar Dredge at each of the 12 sampling locations (see Figure 3-6) on Clear Creek and Big Coldwater Creek. Each sample will be 0.333 m^2, for a total area sampled of 1.0 m^2 at each station. Each grab sample will be immediately placed in a holding tub. The materials will then be washed through a 1-cm screen to hold back large woody debris or leaves. The large items will be discarded after close inspection for clinging organisms. The material washed through the 1-cm screen will then be washed through a 0.5-mm screen. Material retained on the 0.5-mm sieve will be washed into a container (large enough to be filled only half way with screened material) and fixed with 70 percent ethanol. The container will be clearly labeled with the station and replicate number, collection date and time, location, and collector's name.

Fish Survey Fish will be sampled using a seine at the 12 sampling stations prior to the benthic sampling in these areas. A seine large enough to sample the entire reach of the stream will be used. One end of the seine will be pulled along one shore while the other end is pulled in the direction of the current in a parallel fashion along the opposite shore. After a distance of 20 to 30 feet, one end of the seine will be worked to the opposite shore and the two ends beached. Fish will be identified, weighed, and measured in the field and returned to the stream unharmed to the extent possible. Species that cannot be readily identified will be weighed, preserved in 70 percent ethanol, and identified later in the laboratory.

3.8.4.3 Domestic Well Survey A survey will be conducted to identify all potential groundwater receptors. Domestic wells and their uses will be identified, by contacting local agencies (e.g., water management district office, public health office, etc.) and possibly by conducting a door-to-door survey in the study area.

3.9 PHASE I SITE-SPECIFIC EXPLORATIONS. The site-specific explorations developed for the RI field program are designed to acquire the data needed to define spatial distribution and magnitude of environmental contamination at the NAS Whiting Field sites and to support ongoing FS activities. The field program will also provide a qualitative assessment of geologic and hydrogeologic conditions at NAS Whiting Field.

To provide a framework for hydrogeologic characterization of the various sites at NAS Whiting Field, a review area for each of the ten sites or cluster of sites was identified. The review area for each site(s) is indicated on the referenced

BIOLOGICAL SAMPLING DATA SHEET
AQUATIC SURVEYS

LOG. NO.________

Site:________________ Type of Sample:____________ Date: ________

Water Body:____________ Number of Samples__________ Time (24 hr clock):________
Location:______________ Equipment Used:____________ Collector(s): ________
County_________________ Weather (present):__________
Township:______________ (past): __________ Preservative(s): ________
Contaminants of Concern:______________________________

Terrain Characteristics: Land Use (500 m radius)

___Urban ___Upland Conifer ___Flat
___Cultivated ___Swamp hardwood ___Rolling
___Pasture ___Swamp Conifer ___Hilly
___Upland hardward ___Marsh ___Mountains

Stream Cover (Overall upstream view)

___Dense (75%-100% shaded)
___Partly open (15-75%)
___Open (0-25%)

Stream Gradient

___Pool
___Riffle
___Cascade
___Flat

Physical Characteristics of Bottom (estimate % of each component over 12m stretch of site)

___Bedrock ___Gravel (1/8"-3) ___Large Woody Debris
___Boulders (>10") ___Sand (<1/8") ___Detritus
___Rubble (3"-10") ___Silt-caly-muck ___Leaf litter

Habitat
Width ( ): ____________________
Depth ( ): ____________________
Flow (c /): __________meter type__________
pH: __________D.O.__________
Water (color, etc.) __________secchi:__________
Immediate shore: ____________________
Temperature Air: __________water__________
Notes: ____________________
____

Observations and Notes: (Check off and describe)

Fish:____________________
Algae:____________________
Macrophytes:____________________
Submergent or emergent:____________________
Invertabrates:____________________
Mammals:____________________
Discharges:____________________
Distance from outfall:____________________
Plume characteristics:____________________
Foreign matter:____________________
Obstructions:____________________
Other:____________________
____

FIGURE 3-9
BIOLOGICAL SAMPLING
DATA SHEET FORM
AQUATIC SURVEYS

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

BIOTA IDENTIFICATION FORM

SAMPLE NO. ________
REPLICATE NO. ______
DATE ______________

GENUS/SPECIES	COUNT	COMMON NAME	REFERENCE/REMARKS

SIGNATURE OF IDENTIFIER ______________________________

FIGURE 3-10

BIOTA IDENTIFICATION FORM

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

site maps. The site-specific explorations will provide a geologic and hydrogeologic assessment of the review area as part of the RI field activities and data evaluation. Each review area assessment will include identification of the direction of groundwater movement, in the geologic units of concern, and an evaluation of contamination.

3.9.1 Sites 1, 17, and 18 The Phase I exploration program for Sites 1, 17, and 18 will include the following activities:

- downhole geophysical logging of monitoring well WHF-1-1, WHF-17-1, and WHF-18-1,
- PCPT/*in-situ* groundwater sampling and analysis at each site, and
- slug tests in existing wells.

In addition, the following optional explorations will be undertaken during Phase II should initial data indicate groundwater contamination:

- plume delineation,
- source area soil sampling, and
- potential receptors survey.

Figure 3-11 shows the approximate locations of the explorations at Sites 1, 17, and 18.

One PCPT exploration each is proposed for Sites 1, 17, and 18 at the positions indicated in Figure 3-11. Prior to the undertaking the PCPT explorations, a synoptic round of water level measurement will be taken in existing wells to assist in the final placement of the PCPT explorations. The results of these explorations plus the geophysical logs for this site grouping will be used to determine if an upper aquifer zone sample should be collected and the approximate depth(s) at which the sample(s) should be taken. An *in-situ* groundwater sample will be collected in the upper aquifer and lower aquifer zones at the approximate depths specified in Table 3-2. Groundwater samples collected during this program will be analyzed for TCL volatile organics at all three sites and TAL metals at Site 1.

3.9.2 Site 3 - Underground Waste Solvent Storage Area The exploration program at Site 3 will consist of the following activities:

- downhole geophysical logging of monitoring wells WHF-3-1 and WHF-3-2,
- two PCPT/*in-situ* groundwater sampling explorations,
- installation of monitoring well WHF-3-3, and
- slug tests in existing wells.

In addition, the following Phase II RI field investigation activities are anticipated:

- plume delineation and
- source area soil sampling.

Figure 3-12 shows the approximate locations of the Phase I explorations at Site 3.

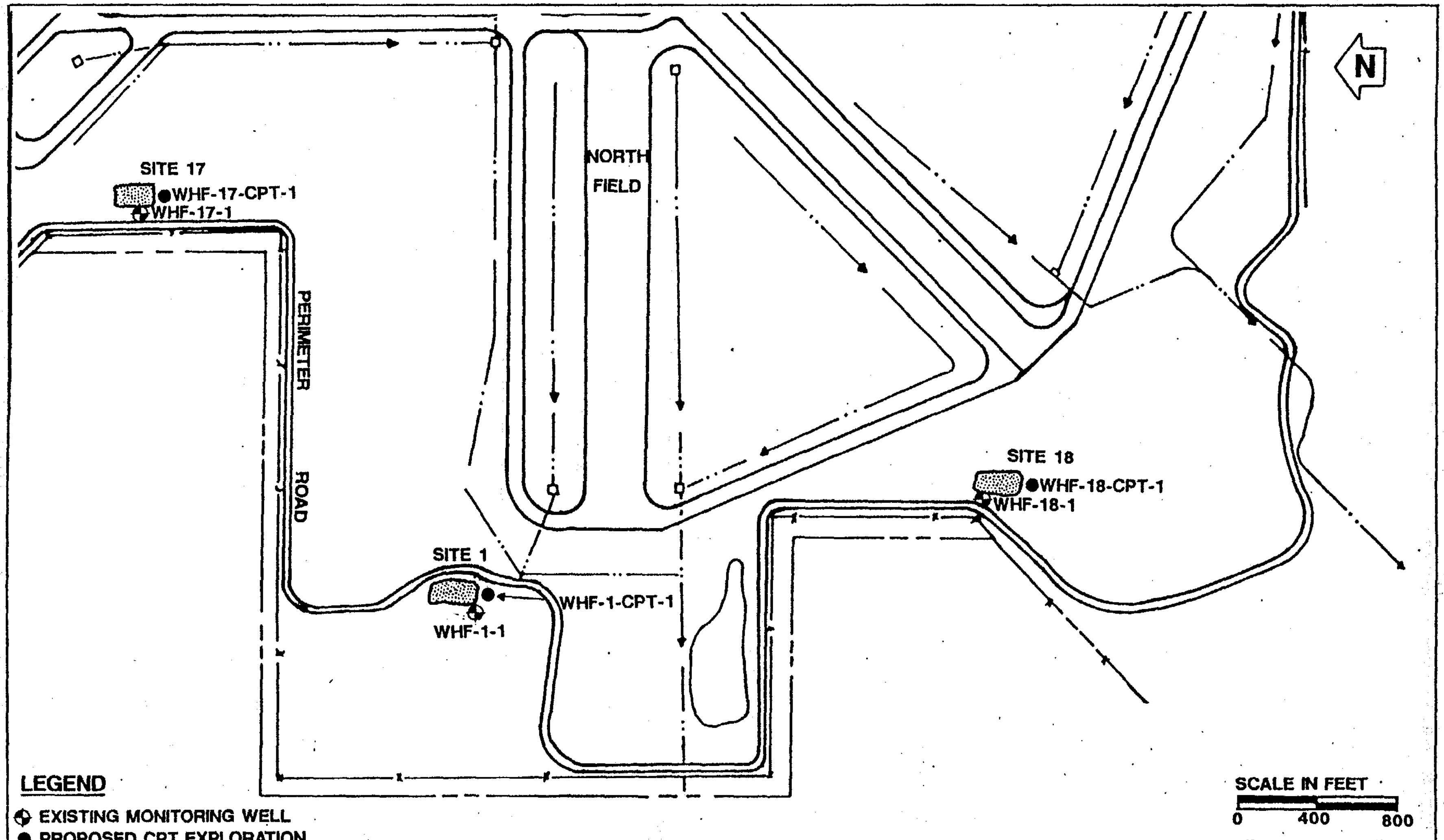


FIGURE 3-11

SITES 1, 17, & 18
EXPLORATION PROGRAM

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

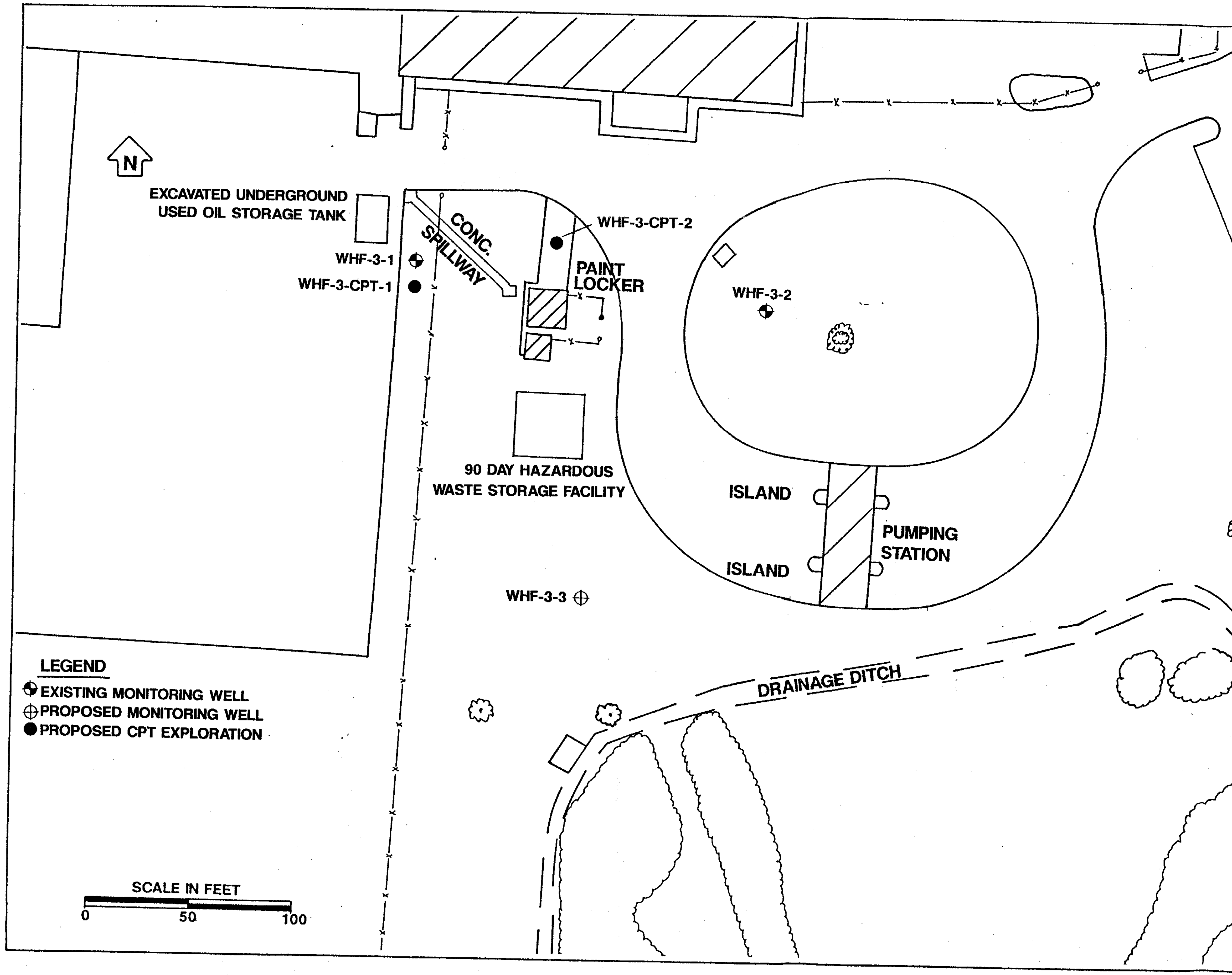


FIGURE 3-12

SITE 3
EXPLORATION PROGRAM

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

00182B052

To aid in the determination of lower aquifer zone groundwater flow direction, monitoring well WHF-3-3 will be installed at the approximate location indicated on Figure 3-12. The depth of this observation well is anticipated to be approximately 150 feet BLS, which corresponds to the screened interval for monitoring wells WHF-3-1 and WHF-3-2. Depth to potentiometric surface as measured in the three wells will be used to plot groundwater flow direction.

Based upon groundwater flow direction, the two PCPT explorations proposed at Site 3 will be sited. The first exploration (WHF-3-CPT-1) will be located to the south of monitoring well WHF-3-1 (see Figure 3-12) and is anticipated to be downgradient of the excavated waste oil tank. The second exploration, WHF-3-CPT-2, is located within the area where the two waste solvent tanks were removed.

Immediately following the PCPT explorations, *in-situ* groundwater samples will be obtained in the same two general areas. Should PCPT data indicate a perched or upper unconfined groundwater body, an *in-situ* groundwater sample will be obtained in this zone. In addition, a lower zone sample will be collected at position WHF-3-CPT-2. No lower zone sample will be obtained from WHF-3-CPT-1 due to its proximity to monitoring well WHF-3-1. Samples will be shipped to the analytical laboratory for the analysis of TCL volatile organics.

<u>3.9.3 Site 6 - South Transformer Oil Disposal Area</u> The exploration program for Site 6 will consist of obtaining 12 surficial soil samples (0.0 to 0.5-foot interval) at the approximate locations indicated on Figure 3-13 (Appendix A). The samples will be forwarded to the analytical laboratory for the analysis of PCBs. Sampling position selected for this study are in locations not originally sampled during the verification study (Geraghty & Miller, 1986). They encompass a small concrete flume leading to the "0-2" drainage ditch. For locations which have been concreted over, samples will be obtained from underneath the concrete flume after a 1-foot square section of flume has been removed. After extraction of the samples, the flume will be patched with concrete.

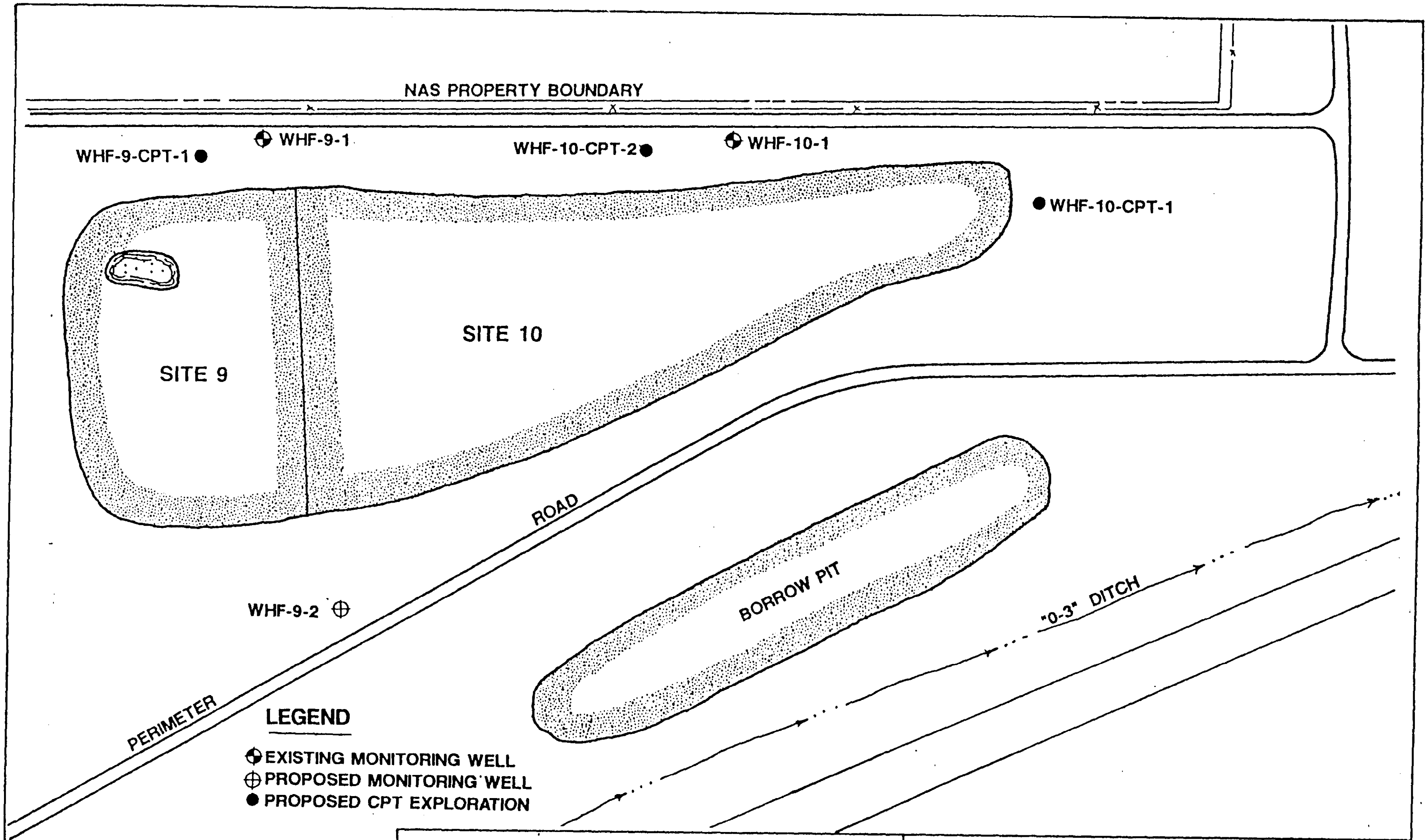
<u>3.9.4 Sites 9 and 10 - Waste Oil Disposal Pit and Southeast Open Disposal Area (A)</u> The exploration program at Sites 9 and 10 will consist of the following activities:

- downhole geophysical logging of monitoring wells WHF-9-1 and WHF-10-1,
- installation of monitoring well WHF-9-2, and
- three PCPT/*in-situ* sampling and analysis explorations.

In addition, the following optional activities will be undertaken during Phase II should the analysis of *in-situ* groundwater samples indicate contamination:

- plume delineation,
- source area soil sampling, and
- potential receptors survey.

To obtain a clear definition of groundwater flow, one monitoring well, WHF-9-2, will be installed at the approximate location indicated in Figure 3-14. The depth of the monitoring well will be approximately 120 feet BLS, which corresponds to the screened interval of monitoring wells WHF-9-1 and WHF-10-1.



N
SCALE IN FEET
0 100 200

FIGURE 3-14

SITES 9 & 10
EXPLORATION PROGRAM

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

Depth to potentiometric surface, as measured in the three wells, will be used to plot groundwater flow direction.

Three PCPT explorations are proposed around Sites 9 and 10 at the approximate locations indicated on Figure 3-14. Initial indications suggest groundwater flow is in a southeasterly to southerly direction and the positions of the PCPT explorations are anticipated to be downgradient of the sites.

Immediately following the PCPT explorations, *in-situ* groundwater samples will be obtained for the analysis of TCL volatile organics and TAL metals. If PCPT data indicate a groundwater body overlying an upper clay layer or lens, *in-situ* samples will be obtained in this zone at all three locations. In addition, a lower aquifer zone *in-situ* groundwater sample will be obtained at location WHF-10-CPT-1. No lower aquifer zone samples are proposed at locations WHF-9-CPT-1 and WHF-10-CPT-2 due to their proximity to existing monitoring wells.

3.9.5 Sites 11, 12, 13, and 14 The exploration program at Sites 11, 12, 13, and 14 will consist of the following activities:

- downhole geophysical logging of monitoring wells WHF-11-1, WHF-12-1, WHF-13-1, and WHF-14-1;
- installation of monitoring well WHF-11-2;
- five PCPT *in-situ* groundwater sampling and analysis explorations;
- drainage ditch sediment sampling; and
- soil sampling at Site 12.

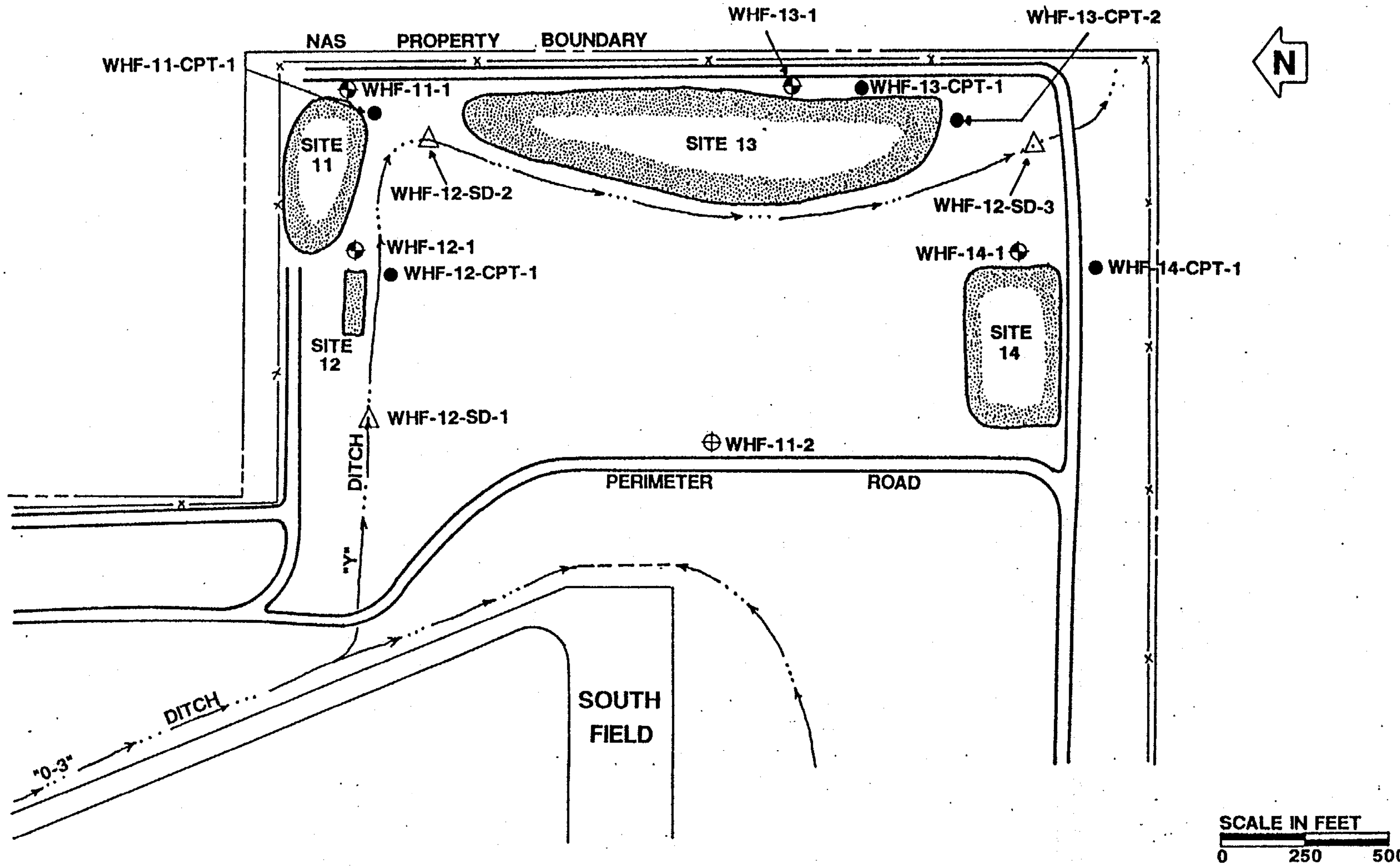
In addition, the following optional activities will be undertaken during the Phase II RI should the laboratory results of the *in-situ* groundwater samples indicate contamination.

- plume delineation,
- source area soil sampling, and
- potential receptors survey.

To clarify groundwater flow, one background monitoring well, WHF-11-2, will be installed at the approximate position shown in Figure 3-15. The depth of the observation well is anticipated to be 150 feet BLS, which corresponds to the screened interval of the existing monitoring wells. Depth to potentiometric surface measurements from the five wells in the area will be used to plot groundwater flow direction.

Five PCPT explorations are proposed within the area of Sites 11, 12, 13, and 14. The approximate locations of the five explorations are presented on Figure 3-15 and are anticipated to be in a downgradient direction of the four sites.

In-situ groundwater samples will be collected in the immediate vicinity of each PCPT exploration. At all five locations a lower aquifer zone groundwater sample will be obtained. If the presence of a groundwater body above the upper clay layer is confirmed during the PCPT explorations, *in-situ* groundwater samples will also be collected from this zone. Groundwater samples will be shipped to the analytical laboratory for the analysis of TCL volatile organics and TAL metals.



LEGEND

- EXISTING MONITORING WELL
- PROPOSED MONITORING WELL
- PROPOSED CPT EXPLORATION
- PROPOSED SEDIMENT SAMPLING LOCATION

FIGURE 3-15

SITES 11, 12, 13, & 14 EXPLORATION PROGRAM

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN SAMPLING AND ANALYSIS

NAS WHITING FIELD MILTON, FLORIDA

Sediment samples will be obtained at three locations within the "Y" drainage ditch (see Figure 3-15). Sediment samples, from the 0.5 to 1.0-foot interval, will be shipped to the analytical laboratory for the analysis of TCL constituents.

Three soil samples will be obtained from each of the two earth covered mounds located at Site 12. Samples will be obtained at a depth interval of approximately 1.0 to 1.5 feet into the mounds. Samples will be shipped to the laboratory for the analysis of total lead and for RCRA hazardous waste characteristics.

<u>3.9.6 Sites 15 and 16</u> The exploration program at Sites 15 and 16 will consist of the following activities:

- downhole geophysical logging of monitoring wells WHF-15-1 and WHF-16-1,
- installation of monitoring well WHF-16-2,
- four PCPT explorations with associated *in-situ* groundwater sampling and analysis,
- drainage ditch sampling, and
- obtaining surficial soil samples.

The approximate locations of the various explorations are presented in Figure 3-16.

The following compose the options which may be invoked if groundwater contamination is detected:

- plume delineation,
- source area delineation, and
- potential receptors survey.

To aid in the calculation of hydraulic gradient and groundwater flow direction, one background monitoring well, WHF-16-2, is proposed for installation (see Figure 3-16).

Four PCPT explorations are proposed in the area of Sites 15 and 16. The location of these explorations are presented in Figure 3-16. Due to the length of the downgradient edge of each site, two explorations are proposed for each site.

Subsequent to the PCPT explorations, *in-situ* groundwater samples will be collected at each location. It is anticipated that two groundwater samples will be collected at each location. However, the collection of an upper aquifer zone groundwater sample will be contingent upon the presence of the upper clay layer or lens. *In-situ* groundwater samples will be shipped to the analytical laboratory for the analysis of TCL volatile organics and TAL metals.

Sediment samples will be obtained at three locations in the old "A" drainage ditch (see Figure 3-16). Samples will be obtained from the 0.5 to 1.5-foot depth interval. Sediment samples will be shipped to the analytical laboratory for the analysis of TCL constituents.

Due to the proximity of past Boy Scout activities to Sites 15 and 16, three randomly located surface soil samples will be collected at each site. Samples

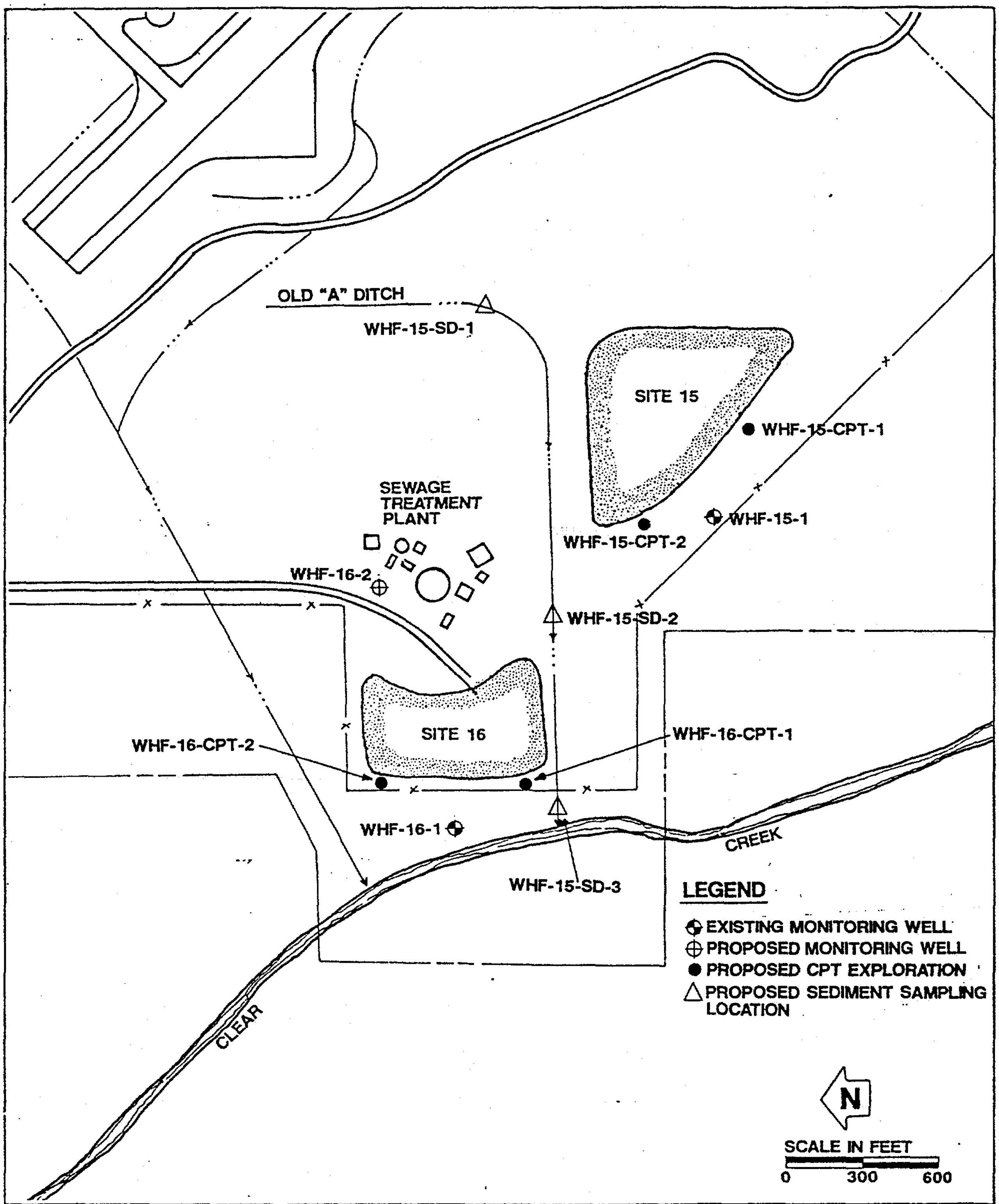


FIGURE 3-16

SITES 15 & 16
EXPLORATION PROGRAM

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

RI/FS WORK PLAN
SAMPLING AND ANALYSIS

NAS WHITING FIELD
MILTON, FLORIDA

will be collected from the 0.0 to 0.5-foot depth interval for the analysis of TCL constituents.

3.10 ANALYTICAL PROGRAM. The analytical program for the Remedial Investigation at NAS Whiting Field is detailed in the Site-Specific Quality Assurance Plan Addendum (Appendix C) and is summarized in Table 3-5. Soil and water samples will be analyzed for TCL organics and inorganics using CLP methods at NEESA Level C QC. Ten percent of soil, sediment, and surface water samples will be replicated and sent to the laboratory for the analysis of TCL organics and inorganics using CLP methods at NEESA Level D QC.

TABLE 3-5
SUMMARY OF CHEMICAL ANALYSES[1]
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

		NEESA LEVEL C REQUIREMENTS						NEESA LEVEL E REQUIREMENTS	
SITE NUMBER	ENVIRONMENTAL MEDIUM	TCL VOAs	TCL SVOAs	TCL PEST/PCBs	TAL INORGANICS	TCL PCBs	TAL METALS	RCRA HAZARD CHARACTERISTICS[2]	TOTAL LEAD
1	Groundwater	2					2		
3	Groundwater	3							
6	Soil					12			
9	Groundwater	1					1		
10	Groundwater	3					3		
11	Groundwater	2					2		
12	Groundwater	2					2		
	Sediment	3	3	3	3				
	Soil							6	6
13	Groundwater	4					4		
14	Groundwater	2					2		
15	Groundwater	4					4		
	Soils	3	3	3	3		3		
	Sediment	3	3	3	3				
16	Groundwater	4					4		
	Soils	3	3	3	3				
17	Groundwater	2					2		
18	Groundwater	2					2		
W-W3	Groundwater	18							
W-S2	Groundwater	16							

TABLE 3-5 (Cont.)
SUMMARY OF CHEMICAL ANALYSES[1]
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

		NEESA LEVEL C REQUIREMENTS						NEESA LEVEL E REQUIREMENTS	
SITE NUMBER	ENVIRONMENTAL MEDIUM	TCL VOAs	TCL SVOAs	TCL PEST/PCBs	TAL INORGANICS	TCL PCBs	TAL METALS	RCRA HAZARD CHARACTERISTICS[2]	TOTAL LEAD
STA1	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA2	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA3	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA4	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA5	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA6	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA7	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA8	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA9	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA10	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA11	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
STA12	Surface Water	1	1	1	1				
	Sediment	1	1	1	1				
SUBTOTAL	Groundwater	65					28		
	Soil	6	6	6	6	12		6	6
	Surface Water	12	12	12	12				
	Sediment	18	18	18	18				

Footnotes at end of table

TABLE 3-5 (Cont.)
SUMMARY OF CHEMICAL ANALYSES[1]
RI/FS WORK PLAN
NAS WHITING FIELD, FLORIDA

SITE NUMBER	ENVIRONMENTAL MEDIUM	NEESA LEVEL C REQUIREMENTS: TCL VOAs	TCL SVOAs	TCL PEST/PCBs	TAL INORGANICS	TCL PCBs	TAL METALS	NEESA LEVEL E REQUIREMENTS: RCRA HAZARD CHARACTERISTICS[2]	TOTAL LEAD
Duplicates	Groundwater	7					3		
	Soil[3]	1	1	1	1	2			
	Surface Water[3]	2	2	2	2				
	Sediments[3]	2	2	2	2				
Matrix Spike/Dup	Soil[3]	2	2	2	2	2			
	Surface Water[3]	2	2	2	2				
	Sediments[3]	2	2	2	2				
Field Blank[4]	Water	11	2	2	2	1	7	1	1
Equipment Blank[5]	Water	36	2	2	2	1	1	1	1
Trip Blank[6]	Water	32							
TOTAL	Groundwater	72					31		
	Soil	9	9	9	9	16			
	Surface Water	16	16	16	16			6	6
	Sediment	22	22	22	22				
	Blank	79	4	4	4	2	8	2	2

NOTES:
1 Listing of sample ID Code in Site-Specific Quality Assurance Plan Addendum
2 Includes analysis for ignitability, corrosivity, reactivity, and TCLP
3 10% replicate at Level D QC requirements
4 1/source/event
5 1/day
6 1/cooler

TCL - Target Compounds List
TAL - Target Analyte List
VOA - Volatile Organic Analytes
SVOA - Semivolatile Organic Analytes
PEST - Pesticides
PCBs - Polychlorinated Biphenyls

REFERENCES

Bouwer, H., and J. Rice, 1976. A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resource Research 12(3): 423-428.

Cooper, H.H., J.D. Bredehoeft, and I.S. Papadopulus, 1967. Response of a Finite-Diameter well to an Instantaneous Charge of Water. Water Resources Research, v. 3, No. 1, p. 263-269.

Envirodyne Engineers, May 1985. Initial Assessment Study of Naval Air Station, Whiting Field, Milton, Florida. NEESA No. 13-072.

Geraghty & Miller, Inc. November 1985. Detection and Monitoring Program, Battery Shop Site, NAS Whiting Field, Florida. 23 p. plus Appendices.

Geraghty & Miller, Inc. December 1986. Verification Study: Assessment of Potential Ground-Water Pollution at Naval Air Station Whiting Field, Florida. 73 p. plus Appendices.

Marsh, O.T., 1966. Geology of Escambia and Santa Rosa Counties, Western Florida Panhandle. Florida Geological Survey Bulletin No. 46, 140 p.

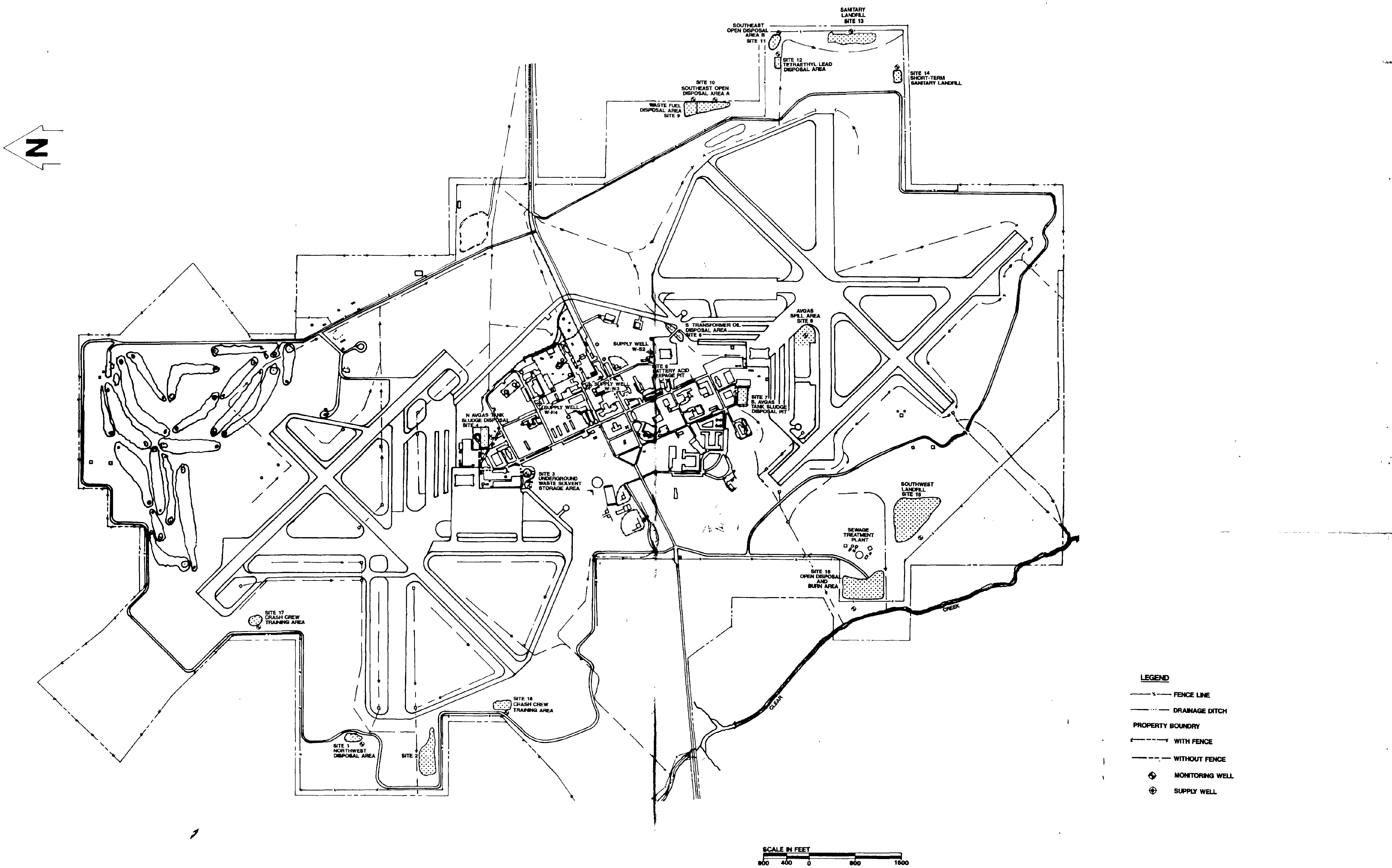
Musgrove, R.H., J.T. Barraclough, and R.G. Grantham, 1965. Water Resources of Escambia and Santa Rosa Counties, Florida. Florida Geological Survey Report of Investigations No. 40, 102 p.

Soil Conservation Service, 1980. Soil Survey of Santa Rosa County, Florida. U.S. Department of Agriculture. 150 p. and Maps

Southern Division, Naval Facilities Engineering Command, 1988. Specifications for Monitoring Well Installation, Revision 3. 10 p.

APPENDIX A

OVERSIZE DRAWINGS



No.	REFERENCE DRAWINGS	SURVEY BY	DATE
1	NAVAL AIR STATION, WHITING FIELD, MILTON, FLORIDA, KEY MAP, GENERAL DEVELOPMENT MAP. NAVFAC DRAWING NO. 5054569, 15 JANUARY 1978.	SURVEY FILE NO	
		FIELD BOOK No	

REV.	DATE	STATUS	MF	BY	CHKD	APPD

E.C.JORDAN CO.

ENGINEERS & SCIENTISTS

CLIENT

SOUTHERN DIVISION
NAVFACENGCOM

DESIGN	
DRAWN	W.W.
CHKD.	
DEPT. HD.	
PROCESS	
PROJ. MGR.	
CLIENT	
SCALE	1 INCH TO 800 FEET

TITLE

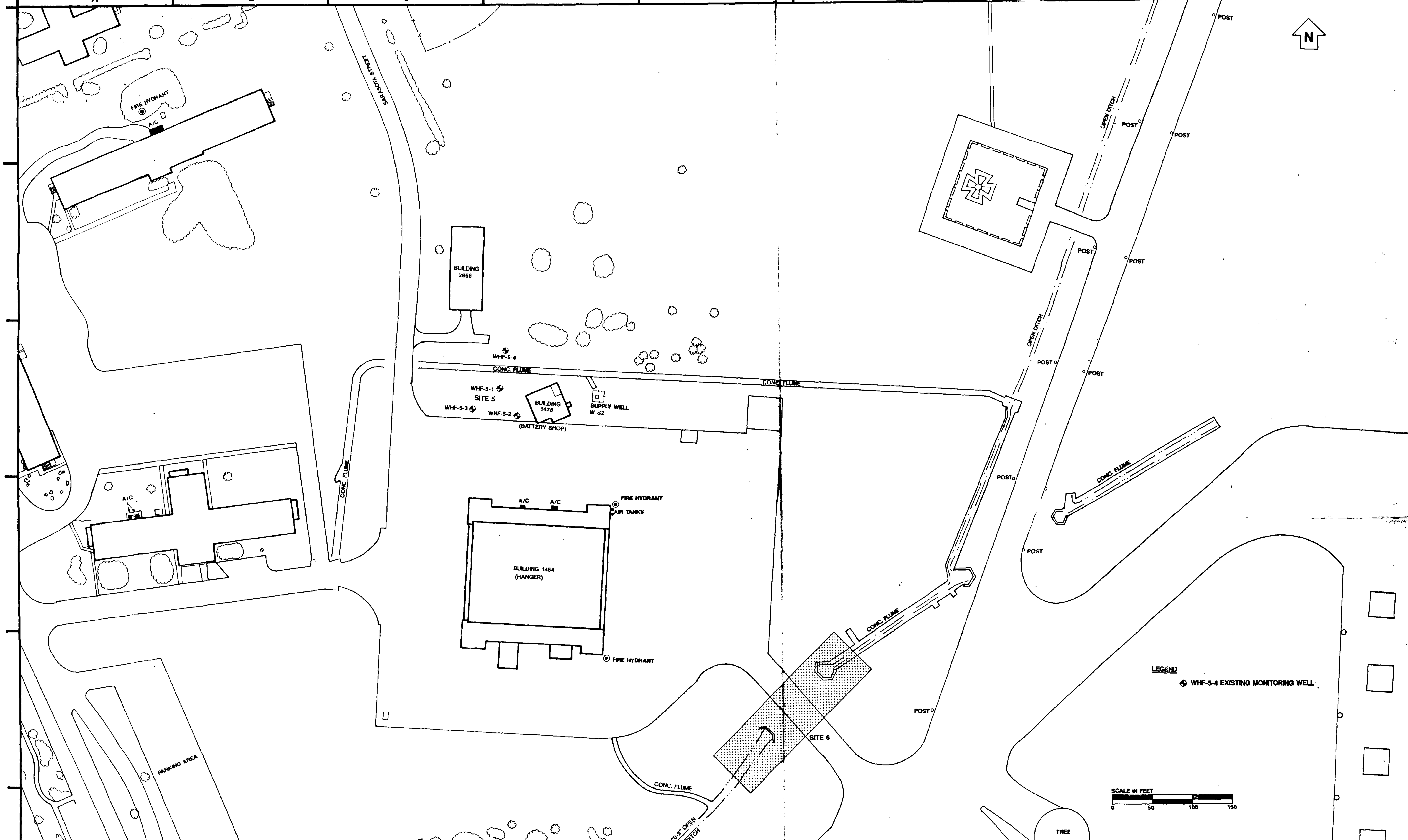
SITE LOCATIONS
NAS WHITING FIELD
MILTON, FLORIDA

PROJ. NO. 5898-01

DWG. NO. 1-3

REV.

00102BB6X



EXISTING CONDITIONS MAP (NO. 11 OF 20) NO DATE

No	REFERENCE DRAWINGS	FIELD BOOK No	REV	DATE	STATUS	MF	BY	CHKD	APPD

SURVEY BY — DATE — SURVEY FILE NO

E.C.JORDAN CO.

CONSULTING ENGINEERS

CLIENT: SOUTHERN DIVISION NAVFACENGCOM

DESIGN		
DRAWN	N.N.	4-23-89
CHKD		
DEPT HD		
PROCESS		
PROJ MGR.		
CLIENT		
SCALE 1 INCH TO 50 FEET		

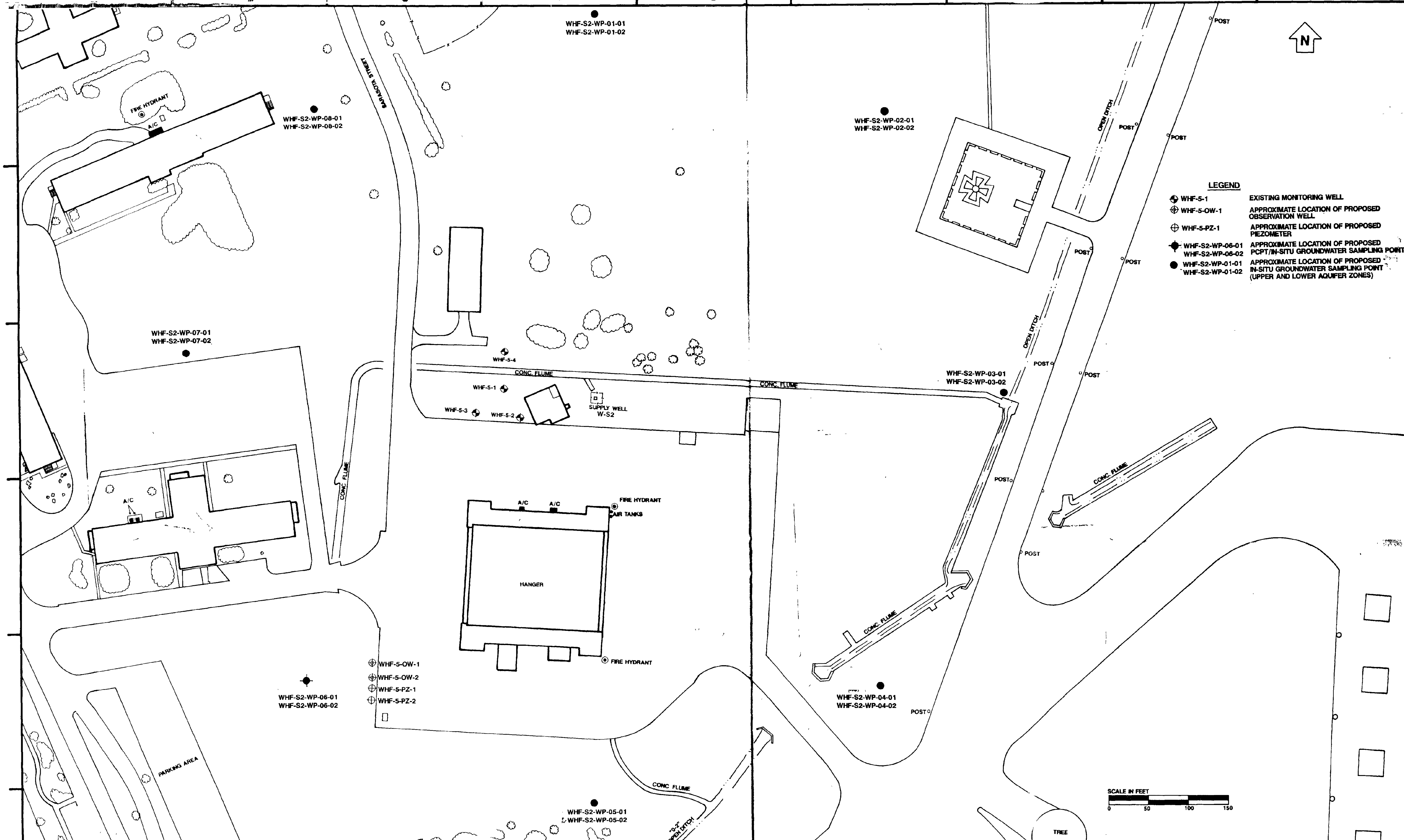
TITLE

SITE PLAN SITES 5 & 6
NAS WHITING FIELD MILTON, FLORIDA

PROJ NO 5898-01

DWG NO 1-6

REV.



No	REFERENCE DRAWINGS
80091	WHITING FIELD - EXISTING CONDITION MAP

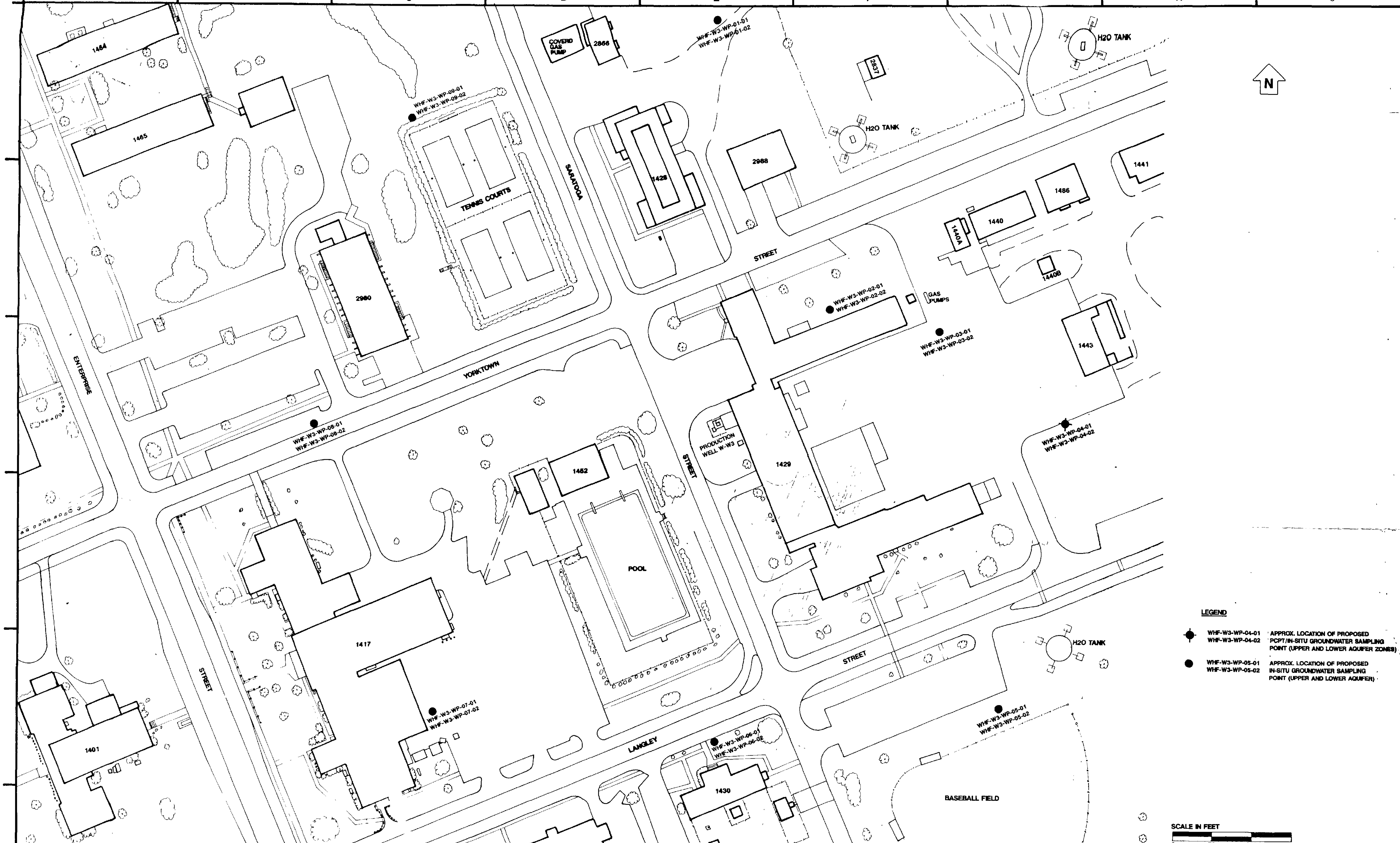
SURVEY BY | DATE | SURVEY FILE NO | FIELD BOOK No | REV | DATE | STATUS | MF | BY | CHKD | APPD

E.C.JORDAN CO.
CONSULTING ENGINEERS

CLIENT
SOUTHERN DIVISION
NAVFACENGCOM

DESIGN	
DRAWN	4-23-89
CHKD	
DEPT HD	
PROCESS	
PROJ MGR	
CLIENT	
SCALE	1 INCH TO 50 FEET

TITLE PRODUCTION WELL W-S2 EXPLORATION PROGRAM
NAS WHITING FIELD
MILTON, FLORIDA
PROJ NO 5898-01
DWG NO 3-5
REV.



No	REFERENCE DRAWINGS	FIELD BOOK No	REV	DATE	STATUS	MF	BY	CHKD	APPD
	WHITING FIELD - EXISTING CONDITIONS MAP	SURVEY BY / DATE / SURVEY FILE NO							

E.C. JORDAN CO.
CONSULTING ENGINEERS

CLIENT
SOUTHERN DIVISION
NAVFACENGCOM

DESIGN
DRAWN W W
CHKD
DEPT HD
PROCESS
PROJ MGR
CLIENT
SCALE 1 INCH TO 50 FEET

TITLE PRODUCTION WELL W-W3 EXPLORATION PROGRAM
NAS WHITING FIELD
MILTON, FLORIDA

PROJ NO 5898-01
DWG NO 3-7
REV.

SARASOTA STREET
FIRE HYDRANT
A/C
CONC. FLUME
SUPPLY WELL
HANGER
AIR TANKS
PARKING AREA
OPEN DITCH
"D-2" OPEN DITCH
POST
TREE
WHF-6-SL-01-01
WHF-6-SL-02-01
WHF-6-SL-03-01
WHF-6-SL-04-01
WHF-6-SL-05-01
WHF-6-SL-06-01
WHF-6-SL-07-01
WHF-6-SL-08-01
WHF-6-SL-09-01
WHF-6-SL-10-01
WHF-6-SL-11-01
WHF-6-SL-12-01
N
LEGEND
SURFACE SOIL SAMPLING LOCATION
SCALE IN FEET
0 50 100 150
EXISTING CONDITIONS MAP (NO. 11 OF 20) NO DATE
SURVEY BY
DATE
SURVEY FILE NO
No
REFERENCE DRAWINGS
FIELD BOOK No
REV
DATE
STATUS
MF
BY
CHKD
APPD
E.C.JORDAN CO.
CONSULTING ENGINEERS
CLIENT
SOUTHERN DIVISION
NAVFACENGCOM
DESIGN
DRAWN
4-23-89
CHKD
DEPT HD
PROCESS
PROJ MGR
CLIENT
SCALE 1 INCH TO 50 FEET
TITLE SITE 6
EXPLORATION PROGRAM
NAS WHITING FIELD
MILTON, FLORIDA
PROJ NO 5898-01
DWG NO 3-13
REV.

APPENDIX B

QUALITY ASSURANCE PROGRAM PLAN

1.0

QUALITY ASSURANCE PLAN - FIELD PROGRAM

UNITED STATES DEPARTMENT OF THE NAVY

INSTALLATION RESTORATION PROGRAM

APPROVED FOR:

E.C. JORDAN CO.

Raymond A. Allen — 5-11-90

Program Manager — Date
Raymond A. Allen, III, CPSS

R. MICHAEL NUGENT — 11.5.90

QA Officer — Date
R. Michael Nugent, Ph.D.

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3.0 PROGRAM DESCRIPTION

3.1 PURPOSE

The purpose of this generalized Quality Assurance Program Plan (QAPP) is to indicate prime responsibilities and prescribe requirements for assuring that the specific site investigations undertaken by E.C. Jordan Co. (Jordan) for the Installation Restoration Program (IRP) are planned and executed in a manner consistent with quality assurance objectives. This QAPP provides guidance and specifications to assure that:

- field determinations and analytical results are valid through preventive maintenance, calibration and analytical protocols;
- samples are identified and controlled through sample tracking systems and chain-of-custody (COC) protocols;
- records are retained as documentary evidence of the quality of samples, applied processes, equipment, and results;
- generated data are validated and their use in calculations is documented;
- calculations and evaluations are accurate, appropriate and consistent throughout the projects; and
- safety is maintained by requiring inclusion of the Health and Safety staff function in the project organization.

3.2 SCOPE

The requirements of this QAPP apply to all Jordan and subcontractor activities as appropriate for each specific project undertaken.

The prime responsibilities indicated in Section 4.0 extend to all quality-related controls and activities. The quality control (QC) and quality assurance (QA) elements described in each section are aimed at preventing isolated sub-standard or erroneous actions from occurring in essential areas.

The content and format of the QAPP is based on "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans - QAMS-005/80" prepared by U.S. Environmental Protection Agency's (USEPA) Office of Research and Development.

This QAPP establishes, among other things, the procedures to be followed for conducting site investigations. Since each site investigation will require data gathering efforts and likely will require field measurements, an addendum to this QAPP will be prepared for each phase of the site investigation. The site-specific QAPP addendum will be included for each phase of the Work Plan.

3.3 PROGRAM SUMMARY

The Department of Defense (DOD) has initiated the Installation Restoration Program (IRP) as a component of compliance with the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) as modified by the Superfund Amendments and Reauthorization Act (SARA). The IRP will be performed in accordance with USN management guidance and in compliance with the requirements of the National Contingency Plan (NCP), the Resource Conservation and Recovery Act (RCRA) and other applicable or appropriate and relevant requirements. The IRP was established by the DOD to identify the locations and contents of past disposal sites at their installations and to eliminate the hazards to public health (both real and potential) in an environmentally responsible manner. The IRP is implemented in the following four phases.

Phase I - Records Search. Phase I consists of an installation-wide records search and personnel interviews to collect and evaluate evidence regarding the potential for contamination at the installation.

Phase II - Confirmation/Quantification. Phase II consists of on-site investigations, including physical and chemical analyses to ascertain and quantify the existence and extent of contamination, and to identify necessary corrective measures if contamination is present. Phase II may consist of one or more stages of investigation to gather data necessary for either eliminating the site from the IRP or implementing Phase IV.

Phase III - Technical Development. Phase III consists of the implementation of research requirements and the development of technology for objective assessment of environmental effects. A Phase III requirement can be identified at any time during the program.

Phase IV - Remedial Actions. The objective of Phase IV is to select and implement control measures that will comply with DOD, USN, USEPA, and state regulatory agency policies regarding past hazardous waste disposal sites. This is usually accomplished in two steps: Phase IV-A, design of remedial actions; and Phase IV-B, implementation of remedial actions.

To facilitate the conduct of the IRP program under the guidelines of the SARA of 1986 and Executive Order 12580, the Phase II/IV-A program will generally be conducted as a Remedial Investigation/Feasibility Study (RI/FS). Phase II activities will generally be referred to as the Remedial Investigation (RI). Remedial Action Planning (Phase IV-A) will generally be referred to as the Feasibility Study (FS).

3.4 MAJOR TASK SUMMARY

The IRP activities to be undertaken at DOD sites by Jordan will consist of scientific and engineering investigations and studies which include multiple tasks and subtasks within each Phase. Each task will be described in the site-specific Work Plan.

3.4.1 Sampling and Analytical Program

Field activities associated with the site investigations will include geophysical explorations and sampling of soil, sediment, surface water, groundwater and air, as appropriate for each site. The specific sampling plan for each site will be described in the task Work Plan and QAPP addendum.

The analytical program is described in Section 9. Analyses will be performed by two laboratories. One laboratory will analyze duplicate samples to provide an external measure of analytical quality. Methodologies may include those utilized by USEPA under the Safe Drinking Water Act (SDWA), CERCLA, SARA, RCRA, and the Clean Water Act (CWA).

3.4.2 Deliverables

Technical progress and financial management reports will be submitted each month. Major reports will be submitted at the completion of each phase. Additional outputs include this QAPP, Work Plans, the site-specific QA addenda, and site-specific Health and Safety Plans (HASP). A specific list of deliverables is to be included in each Work Plan.

3.4.3 Schedule

The Work Plans will include a schedule of activities for each site.

4.0 PROGRAM ORGANIZATION AND RESPONSIBILITIES

4.1 ORGANIZATION

Jordan operates under a matrix system in which personnel belong to functional departments and, at the same time, are assigned to projects. Functional departments are responsible for developing and maintaining Jordan's engineering and scientific disciplines. They provide for personnel training and the establishment of engineering and scientific standards. Each project's organization is responsible for complying with program guidelines and achieving project objectives.

This portion of the QAPP addresses the program organization. Those who are assigned to a project within the program organization are responsible for properly utilizing functional organization resources. In this way, the entire resources of Jordan are made available to each project, but responsibility for initiating services and for ensuring acceptable results remains within the program organization. This responsibility carries with it the authority to initiate, modify, and, if necessary, stop activities, as appropriate for the assurance of project quality. It is the Quality Assurance Coordinator's (QAC) role to assist the Task Order Managers (TOM) in meeting project goals while providing an independent evaluation of product quality.

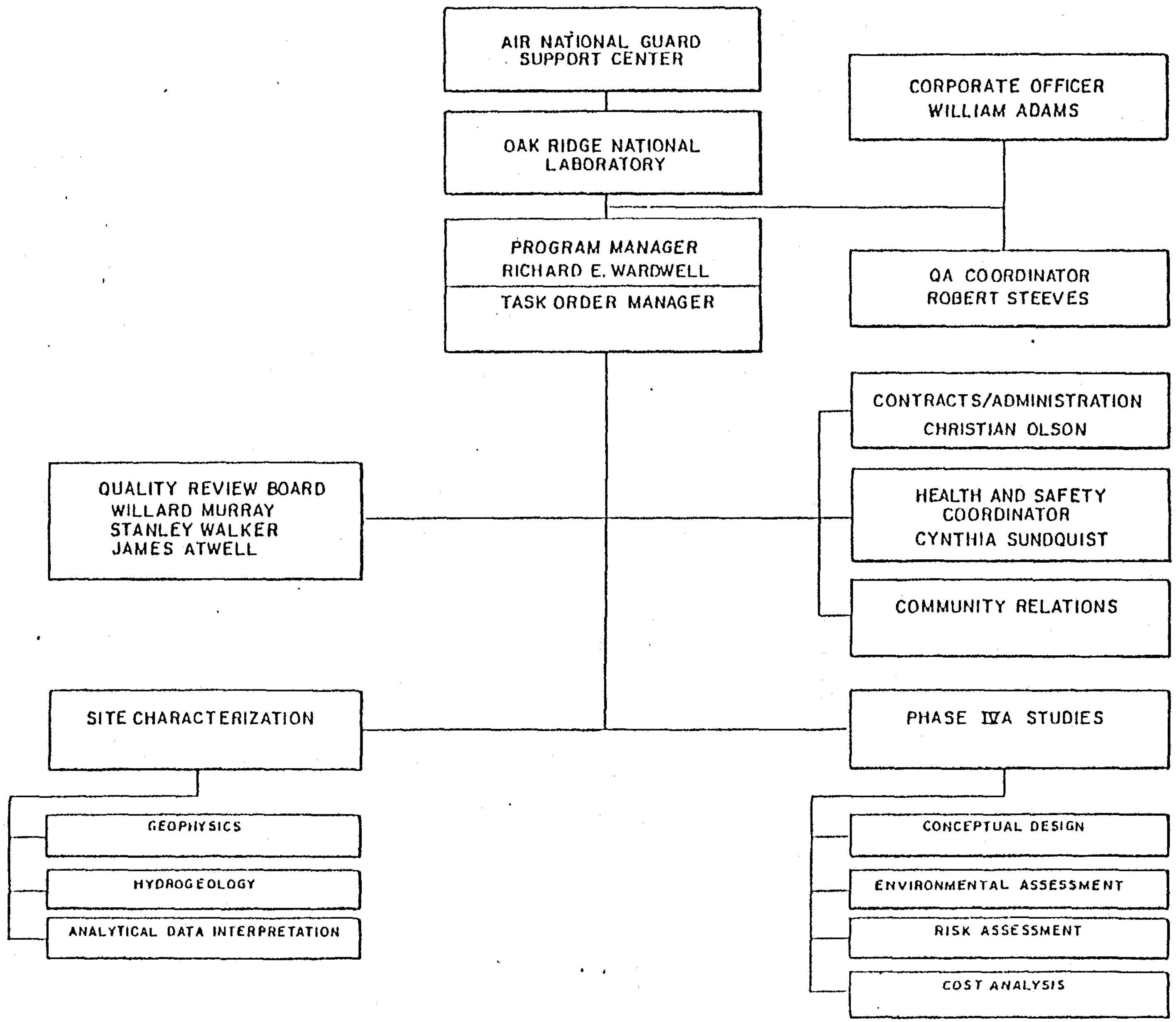
4.2 SPECIFIC RESPONSIBILITIES

Figure 4-1 shows a typical program organization and its principal lines of communication. The responsibilities of the Jordan program positions and support organizations are summarized below.

Regional Officer. The Regional Officer (RO) is James R. Wallace, P.E., Southeast Division Manager. He is responsible for establishing a contract for the services to be performed and for committing the corporate resources necessary to conduct the program work activities; for supplying corporate-level input for problem resolution; and for assisting the Program Manager and Technical Director as needed in project implementation.

Program Manager. The Program Manager (PM), Raymond A. Allen, III CPSS, is responsible for the overall program. Some specific responsibilities of his role include:

- overall technical responsibility for the program;
- establishing and overseeing all subcontracts for support services;
- initiating program activities;



FIC RE 4-1
TYPICAL PROGRAM ORGA ZATION

- implementing the subcontracting plan to significantly involve small and/or disadvantaged business in the program;
- participating in the work plan preparation and staff assignments;
- identifying and fulfilling equipment and other resource requirements;
- monitoring task activities to ensure compliance with established budgets, schedules, and the scope of work;
- regularly interacting with the IRP Management Team, the CO and others, as appropriate, on the status of the project;
- preparing monthly technical/management/cost progress reports; and
- ensuring that appropriate financial record and reporting requirements are met.

Project Manager. Mr. Allen will also hold the positions of Project Manager (PrM). This senior-level position is established because of the importance of day-to-day scope, schedule and budget monitoring both within Jordan and between Jordan and the IRP Management Team. It is expected that program decisions will be occurring frequently, therefore it is necessary to anticipate and immediately implement the administrative actions (initiate internal work orders, follow-up on support needs, amend subcontracts, track cost-charges) to carry out the program plans.

Technical Director. Each site investigated under the IRP will be assigned a Technical Director (TD). Mr. R. Michael Nugent, Ph.D., has been assigned the TD for this project.

The TD is responsible for the following:

- the appropriateness and adequacy of the technical or engineering services provided;
- developing the technical approach and level of effort required to address each of the tasks/subtasks;
- the day-to-day conduct of the work, including the integration of the input of supporting disciplines and subcontractors, (i.e., drilling and laboratory subcontractors);
- ongoing quality control during performance of the work; and
- the technical integrity as well as the clarity and usefulness of all project work products.

Technical Review Board. A Technical Review Board (TRB), made up of senior technical staff from the Jordan team, will assist the PrM and TD by providing review of the technical aspects of the project to assure that the services reflect the accumulated experience of the firms; that they are produced in accordance with the corporate policy; and meet the intended needs of the IRP

Management Team. The primary function of this board is to assure the application of technically sound methodologies and the development of litigatively defensible data, interpretations and conclusions. Members of the TRB will be identified in each Work Plan.

<u>Quality Assurance/Health and Safety Coordinators</u>. The TD is supported by a Quality Assurance Officer (QAO) and a Health and Safety Officer (HSO). These staff-level positions will report to the PM. The QAO will assure that appropriate IRP and USEPA protocols are followed and will be responsible for the development of the task-specific quality assurance addendum. The QAO works with the PM/TD to insure that established quality control procedures are implemented. The HSO is responsible for insuring that the project team complies with Jordan's Health and Safety Program. She is also responsible for seeing that a health and safety plan is developed for each site activity.

Other key line positions are the technical activity leaders, i.e., the senior and/or most-experienced individual in each technical area of the project. These technical activity leaders are identified on the Project Organization Chart in each Work Plan.

5.0 QUALITY ASSURANCE OBJECTIVES

5.1 GENERAL

The quality of measurements made during this study will be determined by the following characteristics: accuracy; precision; representativeness; completeness; and comparability. Specific objectives for each characteristic are established to develop sampling protocols, and identify applicable documentation, sample handling procedures and measurement system procedures. These objectives are established based on site conditions, objective of the project, and knowledge of available measurement systems. The subsequent use of these measurements in calculations and evaluations is also subjected to aspects of this QAPP as described in the following sections.

5.2 REPRESENTATIVENESS

Measurements will be made so that results are as representative of the media (e.g., air, soil, water) and conditions being measured, as possible. Sampling protocols will be developed to assure that samples collected are representative of the media. Sample handling protocols (e.g., storage, transportation) are selected to protect the representativeness of the collected sample. Proper documentation will establish that protocols have been followed and sample identification and integrity assured.

Sample collection and field handling will be in accordance with the standard procedures contained in this QAPP.

5.3 PRECISION AND ACCURACY

Precision, the ability to replicate a value, and accuracy, the ability to obtain a true value, are addressed for all data generated. Data quality objectives for precision and accuracy are established for each major parameter to be measured at the site. These objectives are based on prior knowledge of the capabilities of the measurement system to be employed, selected in accordance with the requirements of the project. The precision and accuracy requirements vary, depending on their intended use. For example, a screening tool to identify the general extent of chemical distribution will not require the same precision and accuracy required to define the exact nature and amount of chemicals present at specific locations. Section 9.2 contains information regarding analytical procedures.

Calculations performed with the data generated are also checked for accuracy by the TD or their designees, and precision, i.e. comparability of calculation efforts between tasks, is assured by the QAO.

5.4 COMPLETENESS

The characteristic of completeness is a measure of the amount of valid data obtained compared to the amount that was expected to be obtained under normal conditions. The amount of valid data expected is established based on the measurements required to accomplish project objectives. The number of groundwater, surface water, sediment, and air samples to be obtained is specified for each site in the QAP Addendum. Because sampling and waste characterization activities often rely on a field protocol, the QAP Addendum would provide an upper limit on the number of samples to be collected. For example, multiple depth soil sample collection may be specified, but rock outcroppings may be encountered prior to reaching the specified depth. In that case, it would not be possible to obtain a predetermined number of soil samples. The extent of completeness must therefore be reviewed on a relative basis for sample collection activities. Completeness of data handling systems is described in Sections 10.0, 12.0 and 14.0.

5.5 COMPARABILITY

The characteristic of comparability reflects both internal consistency of measurements made at the site and expression of results in units consistent with other organizations reporting similar data. Each value reported for a given measurement should be similar to other values within the same data set and within other related data sets. Comparability of data and measuring procedures must also be addressed. This characteristic implies operating within the calibrated range of an instrument and utilizing analytical methodologies which produce comparable results (e.g., data obtained for total recoverable phenolics via wet chemistry is not necessarily comparable to data obtained for phenol via Gas Chromatography/Mass Spectrometry (GC/MS)).

Measurements compared to similar measurements which appear as "outliers" will be reassessed. Units of measurement will be externally comparable by utilizing the appropriate standard units for each measurement system.

5.6 QUALITY ASSURANCE OBJECTIVES

For Jordan's efforts under the IRP, the quality assurance objectives are:

- to collect sufficient background information and current chemical characterization data to assess each site and recommend action alternatives;
- to collect sufficient field, sampler and trip blank samples and field duplicates to allow an assessment of sample representativeness and sample collection protocol precision;
- to analyze sufficient internal duplicates, blanks, reference standards and matrix spike samples to allow an assessment of analytical precision and accuracy. Sufficiency of analytical QC procedures is specified by the referenced methods (see Section 9.2); and
- to produce documented, consistent and technically defensible reports.

6.0 SAMPLING PROCEDURES

6.1 GENERAL

The quality of sample collection techniques is assured by keying the sampling technique used to both the media/matrix to be sampled and the analytes of interest. For example, samples intended for semi-volatile organic analyte (SVOA) analyses are collected in glass bottles; samples for volatile organic analyte (VOA) analyses are collected in Teflon-septum-capped glass vials with "zero" headspace to minimize diffusive and evaporative losses; and most samples for inorganic analyses are collected in linear polyethylene bottles. Sample containers provided by Jordan are prepared in a manner consistent with USEPA protocol, as noted in the following section.

Acquisition of environmental samples also requires specialized collection techniques to preserve their integrity and ensure that a representative portion of the source is collected. Media-specific sample collection techniques are specified in the following sections.

Further, unless the proper sample bottle preparation and sample preservation measures are taken in the field, sample composition can be altered by contamination, degradation, biological transformation, chemical interactions, and other factors during the time between sample collection and analysis. Typical sample bottle preparation protocols are presented in Section 6.2. Steps taken to maintain the in-situ characteristics required for analysis may include refrigeration of samples at 4°C, freezing, pH adjustment, and chemical fixation. Samples are preserved according to the protocol established for the specific analytical method selected to obtain the desired data. Tables 6-1 and 6-2 provide more specific information.

Sample Labels and Records

Sample labels will be prepared prior to initiation of work, generally using the computerized label system. Each sample will require several containers dependent on the intended analysis to be performed. The pH and specific conductance of each aqueous sample will be determined in the field. At the time the sample is obtained, a sample record will be completed. In addition to the sample record, documentation will include:

- a plan of the site;
- sample label numbers;
- a description of the sample site;
- other physical descriptors of the sample site (e.g., stream width, groundwater depth, etc.);

TABLE 6-1
SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS
CERCLA/RCRA SAMPLES

	Concentration	Container	Sample Size	Preservation	Holding Time
WATER					
Organics GC & GC/MS	VOA	glass	2 x 40 mℓ	Cool to 4°C	7 days
	Extractables Low	amber glass	2 x 80 oz. or 4 x 1 ℓ	Cool to 4°C	5 days to extraction 40 days after extraction
	Medium	wide-mouth glass	4 x 32 oz.	None	Same as above
Inorganics	Metals Low	polyethylene	1 ℓ	HNO_3 to pH ≤ 2	6 months (Hg-28 days)
	Medium	wide-mouth glass	16 oz.	None	6 months
	Cyanide Low	polyethylene	1 ℓ	NaOH to pH >12	14 days
	Medium	wide-mouth glass	16 oz.	Cool to 4°C	
Organic/Inorganic	High Hazard	8-oz. wide-mouth glass	6 oz.	None	14 days
COD	--	polyethylene	0.5 ℓ	H_2SO_4 to pH <2	28 days
TOC	--	polyethylene	0.5 ℓ	HCl to pH <2	28 days
Oil & Grease	--	glass	1.0 ℓ	H_2SO_4 to pH <2	28 days
Phenols	--	glass	1.0 ℓ	H_2SO_4 to pH <2	28 days
General Chemistry	--	polyethylene	1.0 ℓ	None	--
SOIL					
Organics GC & GC/MS	VOA	2 oz. wide-mouth glass	2 oz.	Cool to 4°C	10 days
	Extractables Low/Medium	4 oz. wide-mouth glass	4 oz.	Cool to 4°C	10 days to extract[illegible] 40 days after extra[illegible]
Inorganics	Low/Medium	4 oz. wide-mouth glass	4 oz.	Cool to 4°C	NA
Organic/Inorganic	High Hazard	8 oz. wide-mouth glass	6 oz.	None	NA
Dioxin	All	4 oz. wide-mouth glass	4 oz.	None	NA
EP Toxicity	All	250 mℓ polyethylene	200 grams	None	NA
AIR					
Volatile Organics	Low Medium	Charcoal or Tenax Tube 7 cm long, 6mm OD, 4mm ID	100 ℓ air	Cool to 4°C	NA

TABLE 6-2
SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS
CWA SAMPLES

Parameter Name	Container[1] Type	Container[1] Size	Preservation[2]	Maximum Holding Time[3]
Bacterial Tests				
Coliform, fecal and total	P,G	250 mℓ	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Fecal streptococci	P,G	250 mℓ	Same as above	6 hours
Inorganic Tests				
Acidity	P,G	100 mℓ	Cool, 4°C	14 days
Alkalinity	P,G	100 mℓ	Cool, 4°C	14 days
Ammonia	P,G	1000 mℓ	Cool, 4°C, H_2SO_4 to pH <2	28 days
Biochemical oxygen demand	P,G	200 mℓ	Cool, 4°C	48 hours
Bromide	P,G	100 mℓ	None required	28 days
Biochemical oxygen demand, carbonaceous	P,G	100 mℓ	Cool, 4°C	48 hours
Chemical oxygen demand	P,G	100 mℓ	Cool, 4°C, H_2SO_4 to pH <2	28 days
Chloride	P,G	100 mℓ	None required	28 days
Chlorine, total residual	P,G	in field	None required	Analyze immediatel[y]
Color	P,G	50 mℓ	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P,G	1 ℓ	Cool, 4°C, NaOH to pH >12, 0.6g ascorbic acid	14 days
Fluoride	P	100 mℓ	None required	28 days
Hardness	P,G	100 mℓ	HNO_3 to pH <2, H_2SO_4 to pH <2	6 months
Hydrogen ion (pH)	P,G	25 mℓ	None required	Analyze immediatel[y]
Kjeldahl and organic nitrogen	P,G	1 ℓ	Cool, 4°C, H_2SO_4 to pH <2	28 days
Metals				
Chromium VI	P,G	100 mℓ	Cool, 4°C	24 hours
Mercury	P,G	150 mℓ	HNO_3 to pH <2	28 days
Metals, except chromium VI and mercury	P,G	1-5 parameters-100mℓ 6-10 parameters-125mℓ >10 parameters-150mℓ	Same as above	6 months
Nonconventional Pollutants				
Nitrate	P,G	100 mℓ	Cool, 4°C	48 hours
Nitrate-nitrite	P,G	50 mℓ	Cool, 4°C, H_2SO_4 to pH <2	28 days
Nitrite	P,G	100 mℓ	Cool, 4°C	48 hours
Oil and grease	G	1 ℓ	Cool, 4°C, H_2SO_4 to pH <2	28 days
Organic carbon	P,G	10 mℓ	Cool, 4°C, HCl or H_2SO_4 to pH <2	28 days
Orthophosphate	P,G	50 mℓ	Filter immediately, cool, 4°C	48 hours
Oxygen, dissolved probe	G bottle and top	in field	None required	Analyze immediatel[y]
Winkler	Same as above	200 mℓ	Fix on site and store in dark	8 hours
Phenols	G	1 ℓ	Cool, 4°C, H_2SO_4 to pH <2	28 days
Phosphorus (elemental)	G	100 mℓ	Cool, 4°C	48 hours
Phosphorus, total	P,G	150 mℓ	Cool, 4°C, H_2SO_4 to pH <2	28 days
Residue, total	P,G	200 mℓ	Cool, 4°C	7 days
Residue, filterable	P,G	200 mℓ	Cool, 4°C	48 hours
Residue, nonfilterable (TSS)	P,G	200 mℓ	Cool, 4°C	7 days
Residue, settleable	P,G	1 ℓ	Cool, 4°C	48 hours
Residue, volatile	P,G	200 mℓ	Cool, 4°C	7 days
Silica	P	see metals	Cool, 4°C	28 days

TABLE 6-2 (Continued)
SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS
CWA SAMPLES

Parameter Name	Container[1] Type	Container[1] Size	Preservation[2]	Maximum Holding Time[3]
Specific conductance	P,G	25 mℓ	Cool, 4°C	28 days
Sulfate	P,G	250 mℓ	Cool, 4°C	28 days
Sulfide	P,G	200 mℓ	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH >9	7 days
Sulfite	P,G	100 mℓ	None required	Analyze immediately
Surfactants	P,G	400 mℓ	Cool, 4°C	48 hours
Temperature	P,G	in field	None required	Analyze
Turbidity	P,G	40 mℓ	Cool, 4°C	48 hours
Organic Tests				
Purgeable halocarbons	G, Teflon-lined septum	40 mℓ	Cool, 4°C, 0.008% $Na_2S_2O_3$[4]	14 days[5]
Purgeable aromatic hydrocarbons	Same as above	40 mℓ	Cool, 4°C, 0.008% $Na_2S_2O_3$[4], HCl to pH 2	14 days[5]
Acrolein and acrylonitrile	Same as above	40 mℓ	Cool, 4°C, 0.008% $Na_2S_2O_3$[4], Adjust pH to 4-5	14 days[5]
Phenols	G, Teflon-lined cap	1 ℓ	Cool, 4°C, 0.008% $Na_2S_2O_3$[4]	7 days until extraction, 40 days after extraction
Benzidines	Same as above	1 ℓ	Same as above	7 days until extraction
Phthalate esters	Same as above	1 ℓ	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines	Same as above	1 ℓ	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$	Same as above
PCBs, acrylonitrile	Same as above	1 ℓ	Cool, 4°C	Same as above
Nitroaromatics and isophorone	Same as above	1 ℓ	Cool, 4°C, 0.008% $Na_2S_2O_3$[4], store in dark	Same as above
Polynuclear aromatic hydrocarbons	Same as above	1 ℓ	Same as above	Same as above
Haloethers	Same as above	1 ℓ	Cool, 4°C, 0.008% $Na_2S_2O_3$[4]	Same as above
Chlorinated hydrocarbons	Same as above	1 ℓ	Cool, 4°C	Same as above
TCDD	Same as above	1 ℓ	Cool, 4°C, 0.008% $Na_2S_2O_3$[4]	Same as above
Volatile Organics	G, Teflon-lined septum	40 mℓ	Cool, 4°C	14 days[5]
Semi-Volatiles	G, Teflon-lined cap	1ℓ	Cool, 4°C	7 days until extraction, 40 days after extraction
Pesticides Tests				
Pesticides	Same as above	1 ℓ	Cool, 4°C, pH 5-9	Same as above
Radiological Tests				
Alpha, beta and radium	P	1 ℓ	HNO_3 to pH <2	6 months

[1] Appropriate sample containers: P = polyethylene, G = glass.

[2] Sample preservation should be performed immediately upon sample collection. For composite chemical samples, each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

[3] Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples (preserved, as required) may be held before analyses and still be considered valid. Some samples may not be stable for the maximum time period given in the table. A permitter or monitoring laboratory is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability.

[4] Use $Na_2S_2O_3$ (sodium thiosulfate) only if chlorine is present.

[5] 7 days if unpreserved.

- photographs of the sample site may be taken showing the sampling equipment and/or unusual conditions (orientation of photograph must be shown on sketch map); and

- chain-of-custody documentation (see Section 7).

Sample Shipment

Preparation of samples for shipment is performed in the following manner:

1. Label bottles with sample number and sample type (e.g. influent to treatment, effluent from treatment). Each sample set will have a unique sample number. Labels will be secured with tape.

2. Check Department of Transportation (DOT) regulations to insure that samples are packaged correctly for transportation. Should any problems or questions arise with preparation of samples for shipment, contact the task leader.

3. Package samples in the approved shipping container. Laboratory paperwork is to be included with the samples. Ensure samples are cooled to recommended temperature prior to sealing shipping container.

4. Ship samples immediately to the appropriate laboratory via an over-night carrier. Laboratory name and address should be clearly marked on the shipping container.

5. Inform the Laboratory Services Coordinator (LSC) that the samples have been shipped.

6.2 PREPARATION OF SAMPLE CONTAINERS

In order to maintain comparability with data to be generated through USEPA's National Contract Laboratory Program (CLP), Jordan has chosen to acquire precleaned sample containers through either I-CHEM RESEARCH INC., the supplier to USEPA-CLP, or through an approved laboratory which utilizes the same procedures. The procedures used by I-CHEM are detailed below.

6.2.1 Semivolatile Organic Analyte Containers (1-liter amber glass bottles and 4oz. clear glass jars)

1. Wash containers, closures, and Teflon liners in hot tap water with laboratory grade non-phosphate detergent.

2. Rinse three times with tap water.

3. Rinse with 1:1 nitric acid.

4. Rinse three times with ASTM Type 1 deionized water.

5. Rinse with pesticide grade methylene chloride.

6. Oven dry.

7. Remove containers, closures, and Teflon liners from oven.

8. Place Teflon liners in closures and place closures on containers. Attendant to wear gloves and containers not to be removed from preparation room until sealed.

6.2.2 Elemental Parameter, Cyanide and Miscellaneous Parameter Containers (1-liter 500, 250, 125 and 60ml clear and 1-liter amber polyethylene bottles)

1. Wash bottles, closures, and Teflon liners with hot tap water with laboratory grade non-phosphate detergent.

2. Rinse three times with tap water.

3. Rinse with 1:1 nitric acid.

4. Rinse three times with ASTM Type 1 deionized water.

5. Air dry in contaminant-free environment.

6. Place liners in closures and place closures on bottles. Attendant to wear gloves and bottles not to be removed from preparation room until sealed.

6.2.3 Volatile Organic Analyte Containers (40ml glass vials and 2-oz glass jars)

1. Wash vials, septa, and closures in hot tap water with laboratory grade non-phosphate detergent.

2. Rinse three times with tap water.

3. Rinse three times with ASTM Type 1 deionized water.

4. Oven dry vials, septa, and closures.

5. Remove vials, septa, and closures from oven.

6. Place septa in closures, Teflon side down, and place on vials. Attendant to wear gloves and vials not to be removed from preparation room until sealed.

6.2.4 Preparation of Pump Tubing

Adequate lengths of 3/8 inch ID Teflon tubing and 3/8 inch ID silicon tubing will be prepared by Jordan if pump tubing is specified for the sampling episode. The tubing preparation procedure is:

1. Pump detergent solution through system for 2 minutes.

2. Pump clean hot water through system for 2 minutes or until clear, whichever is longer.

3. Pump blank water through system for 2 minutes.

4. Pump decontamination fluid specified in the site specific QAPP through system for 2 minutes.

5. Pump blank water through system for 2 minutes.

6. Seal tubing ends, wrap and label with date of cleaning.

6.2.5 Automatic Composite Sample Containers

The Jordan procedure for cleaning the 5-gallon, 3-gallon, or 2½-gallon glass bottles is:

1. Wash bottles and Teflon-lined caps thoroughly with hot detergent water.

2. Rinse bottles and Teflon-lined caps with hot tap water.

3. Rinse bottles and Teflon-lined caps with blank water.

4. Allow bottles to completely dry.

5. In a well ventilated area (e.g., a laboratory hood), rinse the bottles with dichloromethane or acetone. Inhalation of dichloromethane is avoided. Rinse the bottles making sure that every part of the bottle comes in contact with the dichloromethane or acetone. Three hundred mℓ can be used to clean up to 16 bottles at one cleaning.

6. Allow bottles to dry in a well-ventilated area for at least 24 hours.

7. Heat Teflon-lined caps at 250°F for one hour or replace Teflon-lined caps with new properly cleaned Teflon.

8. After bottles have dried, cap the bottles using a pair of surgical gloves.

6.3 DECONTAMINATION PROCEDURES

Equipment to be decontaminated during the project may include: (1) drill rig; (2) tools; (3) monitoring equipment; (4) respirators; (5) sample containers; (6) truck or trailer and (7) laboratory equipment.

All decontamination will be done by personnel in protective gear appropriate for the level of decontamination, determined by the Site Safety Officer. The decontamination work tasks will be split or rotated among support and work crews. Decontamination procedures within the trailer (if used) should take place only after other personnel have cleared the "hot area", moved to the clean area and the door between the two closed.

Miscellaneous tools and samplers will be dropped into a plastic pail, tub or other container. They will be brushed off and rinsed (outside, if possible) and transferred into a second pail to be carried to further decontamination stations. They will be washed with a non-phosphate detergent solution, rinsed with pesticide grade ethanol:methanol 90:10 v/v (if required), rinsed with a detergent solution and finally rinsed with deionized water. Well screen and riser pipe shall be cleaned in a manner similar to that for drill rigs.

6.3.1 Drilling Rig/Backhoe and Tools

It is anticipated that the drill rigs, backhoes, downhole tools, and well riser pipe and screen will be contaminated during test pit/borehole activities. They will be cleaned with high pressure water or portable high pressure steam followed by soap and water wash and rinse. Other solvents may be used if necessary. Loose material will be removed by brush. The person performing this activity will usually be at Level D protection plus splash protection.

6.3.2 Sample Containers

Exterior surfaces of sample bottles will be decontaminated prior to packing for transportation to the analytical laboratory. Sample containers will be wiped clean at the sample site, but it will be difficult to keep the sample containers completely clean. The samples will be taken to the decontamination area. Here they will be further cleaned as necessary and transferred to a clean carrier and the sample identities noted and checked off against the chain-of-custody record. The samples, now in a clean carrier, will be stored in a secure area prior to shipment.

6.3.3 Monitoring Equipment

Monitoring equipment will be protected as much as possible from contamination by draping, masking or otherwise covering as much of the instruments as possible with plastic without hindering the operation of the unit. The HNU meter, for example, can be placed in a clear plastic bag which allows reading of the scale and operation of the knobs. The HNU sensor can be partially wrapped, keeping the sensor tip and discharge port clear.

The contaminated equipment will be taken from the drop area and the protective coverings removed and disposed of in the appropriate containers. Any direct or obvious contamination will be brushed or wiped with a disposable paper wipe. The units can then be taken inside in a clean plastic tub, wiped off with damp disposable wipes and dried. The units will be checked, standardized and recharged as necessary for the next day's operation. They will then be prepared with new protective coverings.

6.3.4 Respirators

Respirators will be decontaminated daily. Taken from the drop area, the masks will be disassembled, the cartridges set aside and the rest placed in a cleansing solution. (Parts will be precoded, e.g., #1 on all parts of mask #1.) After an appropriate time within the solution, the parts will be removed and rinsed off with tap water. The old cartridges will be marked so as to indicate length of usage (if means to evaluate the cartridges' remaining utility are available) or will be discarded into the contaminated trash container for disposal. In the morning the masks will be re-assembled and new cartridges installed if appropriate. Personnel will inspect their own masks to be sure of proper readjustment of straps for proper fit.

6.3.5 Decontamination Trailer or Truck and Staging Area

The decontamination trailer or truck, if used, will be cleaned daily. This will include vacuuming with a vacuum having a water filter to capture dust particles. The area will be wet mopped with cleanser and again with clean water. Work bench areas will be wiped down. Wash buckets and the cleaning area will be decontaminated and made ready for the next day's use.

6.3.6 Laboratory Equipment

Sample handling areas and equipment will be cleaned/wiped down daily. Disposable wipes will be used and discarded into a plastic bag. These will subsequently be taken to and placed in the disposal drum for final disposition. For final cleanup, all equipment will be disassembled and decontaminated. Any equipment which cannot be satisfactorily decontaminated will be disposed of (e.g., glassware, covers for surfaces) as previously indicated.

6.4 SAMPLING SITE LOCATION

The rationale for each sampling site location is identified in the site work plan. To permit proper evaluation of the sample analysis results it is important that the actual location of the samples be properly documented. If possible, sampling sites will be marked in the field with stakes or flagging. All sampling site locations will be accurately referenced on a base map. Photographs of sampling sites are taken as necessary to document site conditions.

6.5 AIR SAMPLING

Short-term sampling is most often utilized when real-time monitoring is desired. Equipment for real-time monitoring must be calibrated according to manufacturer's instructions prior to use. Typical equipment includes:

- oxygen deficiency meter;
- combustible gas monitor (explosimeter);
- chemically reactive indicating tubes (e.g., Drager) for specific compounds (HCN, H_2S etc.);
- photoionization (PI) survey meter (total volatile organics); and

- organic vapor analyzer (OVA) (total or specific volatile organics).

All real-time monitoring results are recorded on the appropriate field data sheets (Figure 6-1).

6.6 SOIL SAMPLING

6.6.1 General

Soil sampling programs are undertaken to define the location, nature and concentration of contaminants in a site subsurface. The location and distribution of contaminants at a given site are governed by many factors, including:

- site operation or waste disposal practices;
- site design;
- site closure;
- waste characteristics;
- site topography and surface drainage;
- climate; and
- site geology.

Development of a soil sampling plan that will effectively reveal the distribution and magnitude of contamination at a specific site requires at a minimum:

- an assessment of the factors listed above;
- evaluation of the methodology and results of any previous sampling and analysis programs which may have been completed at the site; and
- definition of the scope and objectives of the project.

A number of techniques have been developed to obtain samples from various depths below the ground surface. The techniques described herein are those normally employed by Jordan. They have been selected to provide practical, efficient means of obtaining samples in a manner consistent with safety protocol and QA/QC requirements. Additionally, they employ equipment that is normally available for use.

AIR QUALITY MONITORING RECORD

SITE ____________________

SAMPLE STATION ____________________

DATE ____________________

ON-SITE TIME-START __________ END ____________________

INSTRUMENT ____________________

AMBIENT WEATHER DATA

TEMP. - °F ____________________

HUMIDITY ____________________

BAROMETRIC PRESSURE ____________________

CONDITIONS (i.e., FOG, RAIN) ____________________

____

WIND SPEED/DIRECTION ____________________

TIME	VALUE	TIME	VALUE	TIME	VALUE	TIME	VALUE

NOTES ____________________

____

____

____

____

____
SIGNATURE

FIGURE 6-1

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The selection of sampling techniques to be employed at a given site is based upon the depth from which samples must be obtained and the nature of the soils to be sampled. The sampling techniques are categorized by the depths at which each is applicable:

- shallow samples are from depths of less than about 5 feet, usually less than 2 feet;
- intermediate samples are from depths up to about 15 feet; and
- deep samples are generally from depths greater than 15 feet.

Maintaining proper records is a significant aspect of sample taking. At the time samples are obtained, the following must be recorded by the sampler:

- sample site location (e.g., grid coordinates baseline station and offset, or the location plotted on a map or aerial photograph);
- sample type and depth;
- date and time of sampling;
- project and sample designations;
- sampler identification; and
- analyses requested.

Additionally, the sampler must initiate chain-of-custody (COC) procedures and describe the sample site in adequate detail to allow the analytical results to be properly interpreted and, if necessary, to allow collection of additional samples from the same sample site. Jordan uses preprinted labels, standardized record forms and photographs to expedite this process and ensure uniformity of records. The sampling protocols and recordkeeping requirements for the types of samples described in the following pages vary according to the sampling techniques. Additional requirements may also be established on a site-specific basis. The entire soil sampling process is designed and conducted in a manner that provides samples suitable for the intended analyses and that are properly documented.

6.6.2 Deep Samples

Objective

To obtain deep soil samples suitable for chemical analysis.

Approach

For soil sampling from depths greater than about 15 feet, borings are usually employed.[1] Borings are normally completed as either cased or augered holes.

Boring Methods

The boring methods employed at a given site are selected on the basis of the site's subsurface conditions. Jordan will prepare detailed drilling specifications that govern the drilling subcontractor's efforts upon awarding of the drilling subcontract which is based on competitive bid. These specifications are modified on a site specific basis to reflect the needs of each project. Principal boring methods are described in the following section.

Cased Borings. Casing is used to support the boring as it is advanced. The casing is driven or drilled to the sample elevation and soil remaining in the interior of the casing is washed out with drilling fluid. Potable water or air is normally used to wash out the casing. The samples are retrieved from undisturbed soils below the bottom of the casing. The advantages of this drilling technique are:

- relative simplicity of procedure;
- relatively low risk of personnel exposure;
- can be used to obtain soil samples from a wide range of subsurface conditions;
- can be used to obtain samples from depths greater than 100 feet; and
- good availability of equipment.

The disadvantages of cased borings arise from the need to use a drilling fluid. When sampling pervious soils, such fluids can permeate ahead of the casing. This can result in contamination of the underlying pervious soils if drilling fluids are recirculated. To prevent contamination, drilling fluids may be used only once. Further, the drilling fluids and cuttings removed from the hole may require collection, containerization, and transportation to a suitable disposal site. When drilling fluids are recirculated, as may be done when drilling through relatively low permeability soils, each borehole will generate relatively small quantities of spoils. However, when new fluid must be continually introduced into the hole, management of drilling fluids and spoils can result in significantly increased cost over auger borings. Management of drilling fluids is further complicated under freezing conditions.

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[1]Backhoes can excavate test pits considerably deeper than 15 feet, however, such deep pits are very difficult to sample at discrete depths. Further, deep test pits can pose significant safety risks. Thus, Jordan does not normally use such pits.

Auger Borings. With this technique, hollow stem augers are advanced into the soil. Drill cuttings are compressed laterally and carried upwards on the auger flights. The bottom of the auger is blocked with a plug while the auger is advanced. When the desired sampling depth is reached, the plug is withdrawn and a sample is obtained from below the bottom of the augers. The advantages of the hollow stem auger technique include:

- relative simplicity of procedure;
- relatively low risk of personnel exposure;
- can be used to obtain soil samples from a wide range of subsurface conditions;
- drilling fluids are generally not required; and
- good availability of equipment.

The disadvantages of the hollow stem auger technique include:

- difficulty in penetrating excessively cobbley or bouldery soils; and
- difficulty in sampling granular soils below the water table since without drill fluids there is no practical means to maintain hydrostatic equilibrium in the borehole. When the plug is withdrawn, water and sediment from outside the augers may enter the borehole, potentially causing contamination and difficulty in sampling undisturbed soil below the bottom of the augers.

Other Methods. Other methods (casing advancer systems, cable tool, mud rotary, and bucket auger) are available. These methods, however, are either similar to those already discussed or not readily applicable to work at contaminated sites. They may, however, be considered for use on a site-specific basis.

Sampling of Test Borings

Types of Samplers. Test boring samples are normally taken from undisturbed soil below the depth of the casing or auger with either a thin wall tube or split spoon sampler.

Thin Wall Tube Sampler - Thin wall tube samplers are used in fine-grained or cohesive soils. Because the tube only causes minor disturbance of the soil being collected, the tubes are typically used to obtain soil specimens for geotechnical laboratory testing. The sampler is lowered to the bottom of the borehole and pushed into undisturbed soil. When the sampler is withdrawn, it contains a cylinder of soil. A thin wall tube consists of thin steel with a sharpened edge, usually about 30 inches long. Typical tubes range from about two inches to four inches in diameter. The tube is attached to a sampler head, containing a check valve which is in turn coupled to the drill rods. After the thin wall sampler has been withdrawn from the boring, it is removed from the drill rod and placed in a frame. The tube is then taken to a laboratory and the cylinder of soil is forced from the tube with a hydraulic jack.

Split Spoon Sampler - A split spoon sampler may be used to sample all types of soil. This sampler consists of a split steel tube or sample barrel threaded at both ends. A sharpened drive shoe secures the bottom of the barrel and an adaptor secures the top. The adaptor is threaded to connect directly to the drill rods and contains a check valve (see Figure 6-2). The split spoon is driven into undisturbed soil below the casing or hollow stem auger (see Figure 6-3). After the sampler has been driven, it is withdrawn from the borehole and the sampler is opened by removing the drive shoe and adaptor.

Sample Collection. The drilling monitor will take charge of the sampling device as soon as it is withdrawn from the borehole and opened. The sample will be collected and documented, employing the procedures as outlined below.

1. Scan the soil with a PI detector and record measurements.

2. Photograph any portions selected for chemical analysis, showing an appropriate visual scale (optional).

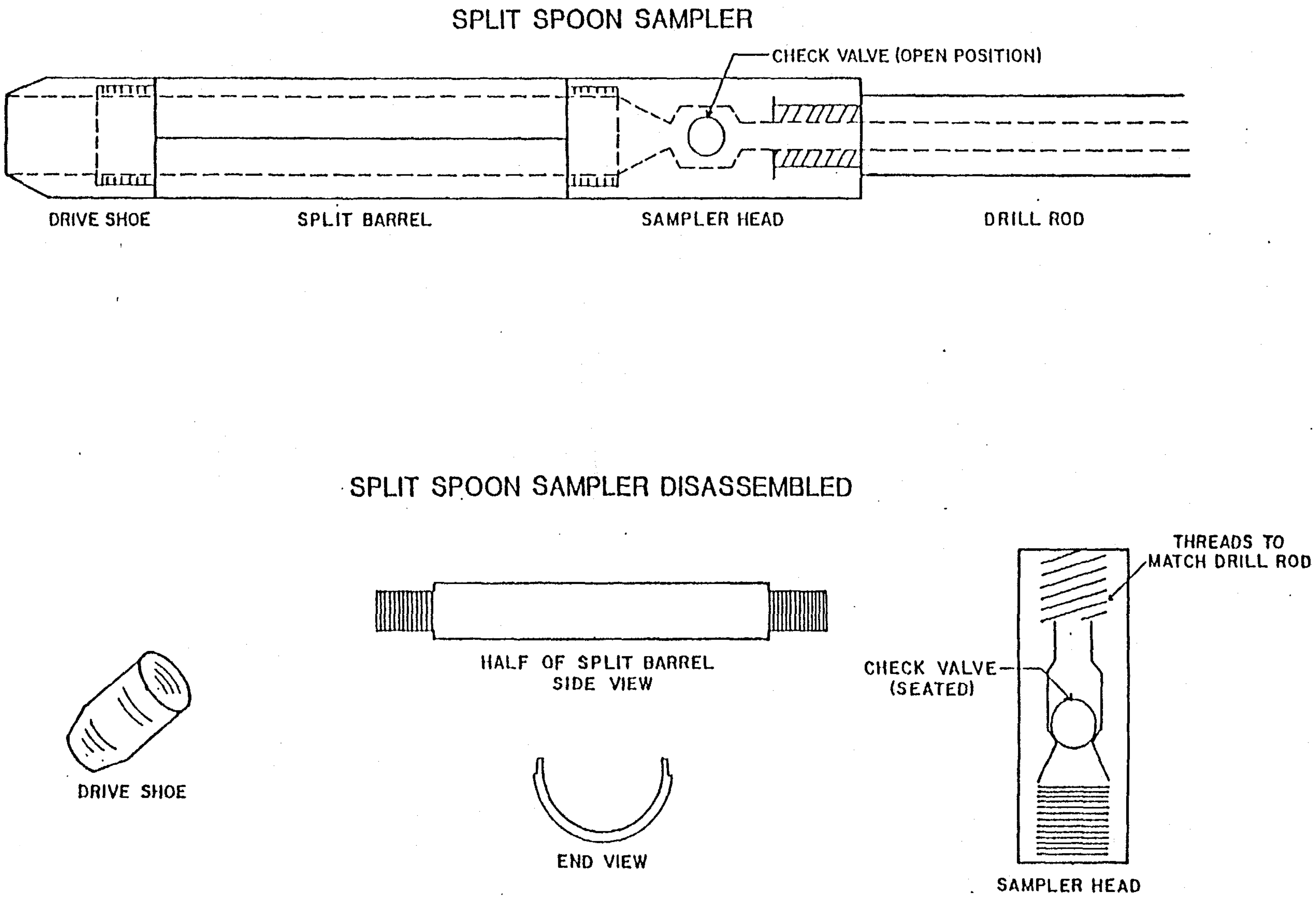
3. Remove the portion(s) of the sample selected for chemical analysis and place it into appropriate containers using a clean spatula. Soil intended for VOA analysis should be placed in 2-oz. wide-mouth glass jar and capped as quickly as possible. The 2-oz. containers should be filled as near to capacity as practicable to minimize volatilization of the sample into the container headspace. Soil intended for other types of analyses should be thoroughly mixed prior to placing it in the remaining containers and capped.

4. Visually examine the sample and record its characteristics (e.g., texture, color, consistency, moisture content, layering and other pertinent data), and classify using the Unified Soil Classification System.

5. Place the remainder of the sample in a 16-ounce "soil jar". This sample portion will be used for headspace PI measurement and for any physical materials testing that is required.

6. Discard any excessively disturbed or loose material found in the sampler which may not be representative of the interval sampled. This material will be discarded with boring spoils at each boring location.

7. Decontaminate the sampling device in accordance with the procedure specified in Section 6.3.



NOTE: NOT TO SCALE

FIGURE 6-2
SPLIT SPOON SAMPLER

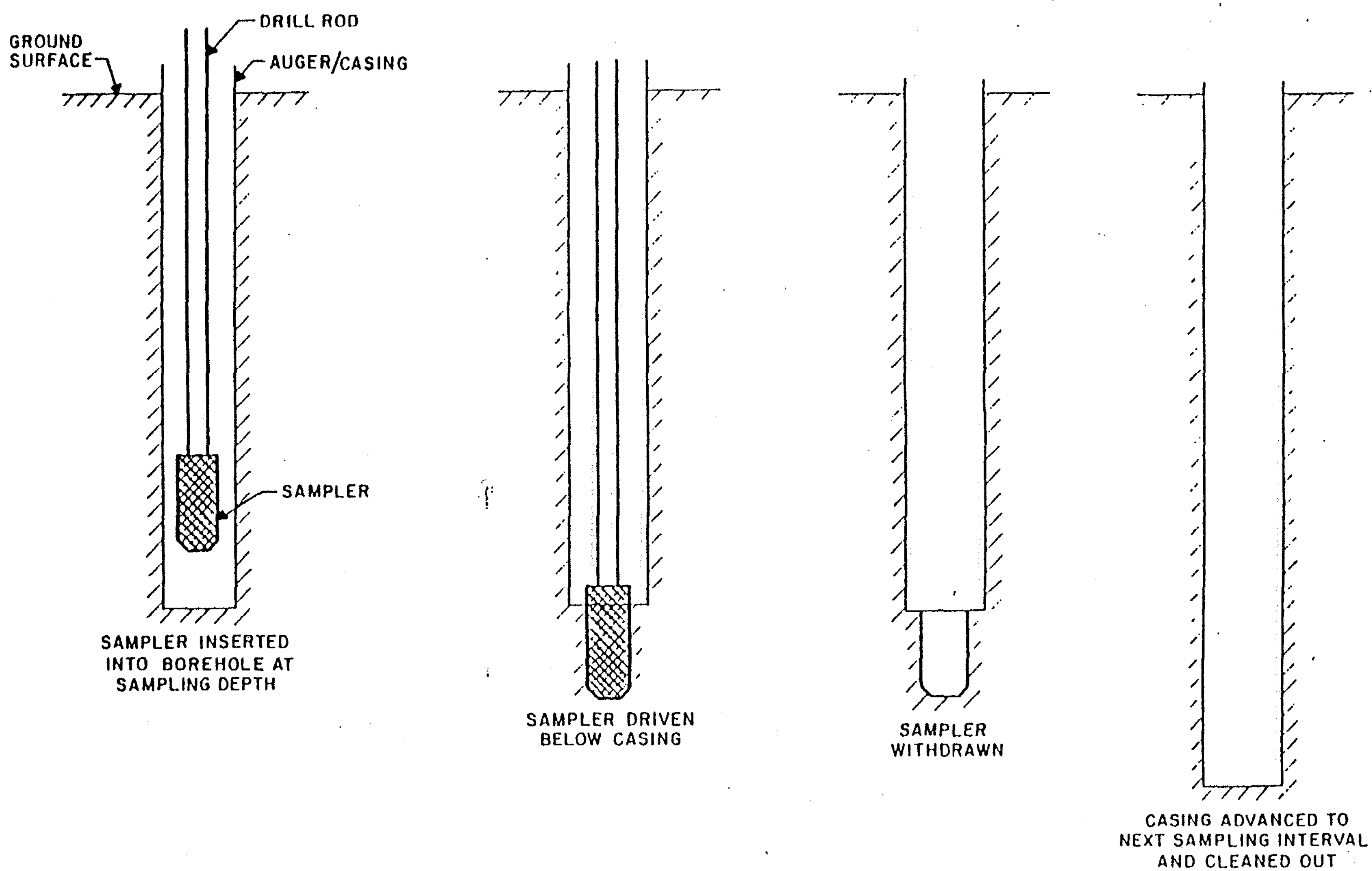


FIGURE 6-3
STEPS IN SAMPLING A TEST BORING

In some instances, none of the samples from a given boring will be prepared for chemical analysis. In these instances, steps 2 and 3 of the procedure listed above are omitted and the sample is placed in one or more "soil jars." Immediately after the samples are collected, all labeled vials and jars are checked for completeness of the sampling objective and chain-of-custody procedures are initiated. The boring log is also updated at this time by the drilling monitor. Boring logs may be completed by the driller, but for purposes of completeness and documentation a separate boring log is also compiled by the drilling monitor. The boring logs will include interpretations of subsurface materials and conditions encountered, sample locations, and other notes pertinent to how the boring was conducted. The drilling monitor's boring log can be completed in a site field book or on a boring log form (see Figure 6-4).

The sampler must exercise considerable care while collecting samples for analysis. Some methods to assure that high quality samples are collected are described below.

1. Make sure that the sample is obtained from undisturbed soil below the casing or auger. This is accomplished by monitoring or checking the drill crew's measurements, observing the sampling process and examining the sample once it is retrieved.

2. Carefully remove and discard portions of the sample that may have become contaminated by contacting the casing, auger, or drilling fluids.

3. Conserve sample volume since under certain soil conditions it may be difficult or impossible to achieve good sample recovery with either split spoons or thin wall tubes.

Procedures employed to prevent cross-contamination during test boring sampling operations include the following:

- Samples are taken immediately after the boring is advanced to the desired sampling elevation.

- The sampling tools are decontaminated prior to taking each sample.

- The drilling contractor is not permitted to use oil, grease or other petroleum based lubricants on the drill rods, casing or sampling tools.

- The drilling technique and procedures to be utilized, particularly the use of drilling fluids, are carefully evaluated for each site.

FIELD LOG SOIL

Boring No.

Project No	Project Name			Page ___ of ___
Contractor	Driller	Date started		completed
Method	Casing Size	HNU 11.7 / 10.2		Protection Level
Ground El.	Soil Drilled	⊻ below ground		Total Depth
Logged by	Checked by	Date		

Sample No	Depth in Feet	Blows per 6 inches	Pen / Rec	Description	HNU jar	Comments on Advance of Boring	Monitoring HNU	Monitoring LEL

FIGURE 6-4

E.C. JORDAN CO.	Boring No	Page ___ of ___

6.6.3 Intermediate Depth Samples

Objective

To obtain soil samples from depths of up to 15 feet for chemical analysis.

Approach

Although test borings can be employed to obtain samples from any depth (as described in Section 6.6.2), backhoe excavated test pits are often more practical and cost effective at intermediate depths.

The major advantages of test pit sampling programs are:

- Samples of any size can be obtained.
- The subsurface is exposed in the test pit revealing the sample site geology and facilitating sample collection and recovery.
- Availability of equipment is good.

There are three factors that must be considered when designing a test pit sampling program:

- the depth at which samples can be effectively obtained;
- site-specific safety issues, including contamination potential and test pit stability; and
- impact on groundwater.

Sampling Procedures

To expedite the sampling and recordkeeping efforts and to minimize periods of potential exposure during the excavation of test pits, the sampling crew will have sufficient tools and equipment to sample each pit prior to requiring decontamination. The backhoe and tools will be decontaminated between each test pit. The backhoe bucket and boom will be decontaminated as required during excavation of each test pit.

The actual layout of each test pit, temporary staging area and spoils pile will be predicated on site conditions and wind direction at the time the test pit is made. During excavation, sampling and logging of each test pit, the backhoe operator and all site personnel will remain upwind or crosswind of the test pit and spoils pile. Wind direction will be monitored by means of a wind sock or other banner located in a prominent position visible to all personnel. Preselection and the use of hand and horn signals is important during completion of test pits due to noise levels around the machine. The sampling crew and backhoe operator will rehearse appropriate signals ahead of time and be thoroughly familiar with their meaning. All personnel should be equipped with air blast horn devices, especially when wearing respiratory safety gear which hinders communication.

Sampling of unopened buried drums is excluded from this test pitting protocol. Jordan undertakes such work on a site-specific basis and utilizes appropriate safety and sampling protocols for each instance.

Test pits are logged as they are excavated. Records of each test pit will be made on prepared forms or in a field book. If the log is made in a field book it will be transcribed to prepared forms. These records include plan and profile sketches of the test pit showing all materials encountered, their depth and distribution in the test pit and sample locations. These records will also include safety and sample screening information. An example test pit record form is shown as Figures 6-5 and 6-5A. Jordan has found this format useful since it provides all necessary sampling, monitoring and subsurface records for each test pit in a concise and uniform manner. This format also provides a cross-check with chain-of-custody records and sample label counts.

The actual depth and type of samples obtained from each test pit will be selected at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may be collected.

Test pits are excavated and sampled in the following manner:

1. The sampler and backhoe operator will plan the excavation.

2. The backhoe operator will excavate the test pit in several depth increments.

3. After each increment, the operator will wait while the sampler inspects the test pit to decide if conditions are appropriate for sampling. Practical depth increments range from 2 to 4 feet.

4. The backhoe operator, who will have the best view of the test pit, will immediately cease digging if:

    - any fluid phase or groundwater seepage is encountered in the test pit,

    - any drums or other potential waste containers are encountered, or

    - distinct changes of material are encountered.

    This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol.

    For instance, should any fluids or seepage be encountered, they could, after suitable screening and monitoring, be sampled. Waste and sludge deposits could likewise be sampled before proceeding. Should uncollapsed drums be encountered, the test pit would be terminated, backfilled and redug at an adjacent location.

TEST PIT RECORD

SITE ____________________

TEST PIT ____________ DATE ____________ TIME ST. ____________ END ____________

COORDINATES ____________________ GRID ELEMENT ____________________

SKETCH MAP OF TEST PIT SITE
(SHOW SURFACE MONITORING RESULTS)

N

WIND

SCALE 1" = _____ FT

CREW MEMBERS

1.

2.

3.

4.

5.

6.

MONITOR EQUIPMENT

P I METER	Y	N
EXPLOSIVE GAS	Y	N
AVAIL. OXYGEN	Y	N
OVA	Y	N

OTHER ____________

____

PHOTOGRAPHS, ROLL ________

EXPOSURE ____________

NOTES ____

____

____

____

____

____

____

____

____

____

____

____

____

FIGURE 6-5

TEST PIT RECORD
PROFILE ALONG TEST PIT-____

SITE ________________________________

DEPTH (FT) SCALE 1" = _____ FT

NOTES:

SAMPLES OBTAINED

NO.	DEPTH (FT)	INIT. SER. NO.	HO. SP. VOA PPM
S-1			
S-2			
S-3			
S-4			
S-5			
S-6			
S-7			
S-8			

REFERENCE: FIELD BOOK, PG. ________
ATTACHMENTS ________

SIGNATURE

FIGURE 6-5A

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5. The test pit is sampled as described in the following sections.

Sampling from Ground Surface. To sample the pit from the ground surface, two methods have been used. The method is selected in the field at the time the test pit is sampled.

a. Samples can be obtained from the backhoe bucket. The sampler or crew chief will direct the backhoe operator to remove material from the selected depth or location within the test pit. The bucket will be brought to the surface and moved away from the pit. The sampler will approach the bucket and monitor its contents with the PI meter. If granular or loose soils and/or uniform materials are encountered, the sample will be obtained directly from the bucket. The sample is collected from the center of the bucket and placed in sample jars using a clean trowel or spatula.

   If a composite sample is desired, several depths or locations within the pit are selected and a bucket is filled from each area. A sample bottle is filled from each bucket and then emptied into a mixing surface (e.g., stainless steel or pyrex pan) and thoroughly stirred prior to being placed into the sample jars. The disposable mixing surfaces are discarded into the test pit when it is backfilled.

   If cohesive soils or multiphase conditions are encountered (e.g., the bucket contains a mixture of soil and sludge) the sampler will proceed as above if practical; if not, he will direct the backhoe operator to empty the bucket onto the ground. He will then obtain the sample from the interior of soil clods or lumps of sludge using a clean trowel or spatula.

b. Samples can be obtained directly from the test pit. This is necessary when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., caving or excessive mixing of soils or wastes within the test pit) or when samples from relatively small discrete zones within the test pit are required. This approach is also required to sample seepage occurring at discrete levels or zones in the test pit. In these circumstances, samples will be obtained by means of extendable handled tools: scrapers, trowels, spoons or cups. The face of the test pit is scraped to remove the smeared zone that has contacted the backhoe bucket. The material to be sampled, if a solid, is then removed from the test pit wall by means of long handled scoops or trowels. The sample is then thoroughly stirred on a clean disposable mixing surface and placed in sample jars. If fluids are removed from the pit they are placed in a mixing jar as obtained. They are then decanted into sample jars.

In-Pit Sampling Safety. While samples can be obtained directly from the test pit, as noted above, it is Jordan policy that personnel will sample and log pits from the ground surface except as provided for by the following criteria:

- The project will benefit significantly from the improved quality of the test pit logging and sampling data obtained if personnel enter a test pit rather than conduct such operations from the ground surface.

- There is no practical alternative means of obtaining such data.

- The site safety officer determines that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the test pit after it is dug (including, at a minimum, measurements of volatile organics, explosive gases and available oxygen).

- An experienced geotechnical professional determines that the test pit is stable or is made stable prior to entrance of any personnel in accordance with 29 CFR 1926.652 (Special Trenching Requirements).

If all of these conditions are satisfied, one person will enter the test pit. On potentially hazardous waste sites, this individual will be dressed in safety gear as required by the conditions in the pit. This person will be affixed to a safety rope and continuously monitored while in the pit. A second individual will be fully dressed in appropriate protective gear and on stand-by during all pit entry operations. The individual entering the pit will remain therein for as brief a period as practical commensurate with performance of his work. After removing the smeared zone, samples are obtained with a trowel or spoon.

Sampling in the Vicinity of Drums. Should collapsed or highly-corroded drums be encountered which are obviously empty and pose no unusual threat, the test pit could be continued after appropriate monitoring. If possible, the test pit is sampled from the ground surface by means of long-handled scoops or trowels. As described above, the face of the test pit must be first scraped to remove the smeared zone that has contacted the backhoe bucket. Attempts to sample drums or containers also could be made from the ground surface, with appropriate safety procedures. After sampling, the test pit would be backfilled.

6.6.4 Shallow Samples

Objective

To obtain samples of surface and near surface soils suitable for chemical analysis.

Approach

Shallow soils samples are usually obtained by using one of the following devices:

- split-spoon sampler;
- hand auger or corer;
- trowel or spoon; and
- spade.

The split-spoon sampler was described in Section 6.6.2. Two distinct types of hand augers are available: a cup-type auger and a screw-type auger. Use of either device is generally limited to the upper portion of the soil profile (less than five feet). These augers are best suited for obtaining composite samples from relatively shallow depths and in relatively loose soils. Use of trowels or spades is straightforward but usually limited to sampling very shallow depths (less than 18 inches).

Soil samples can be either grab or composite, depending on the objective of the sampling program. In grab sampling, the soil jar can be filled directly which is usually desirable for VOA samples. In composite sampling, several methods are available:

- Samples can be composited over depth at a single spot.
- Samples can be composited laterally, in which one sample is comprised of several (usually three or four) soil specimens in the vicinity of the sampling site.

Composite samples are mixed in the same manner as composite test pit samples (see Section 6.6.3). Samples for volatile organic constituent analysis should not be composited.

Immediately after taking a sample, the sampler fills the containers required for the requested analyses, attaches the labels, initiates COC procedures and completes the field sample data record.

6.6.5 Sediment Samples

Objective

To obtain samples of the sediment found in streams, ponds or other water bodies for chemical analysis.

Approach

Sediment samples are usually taken in conjunction with surface water samples to help define the partitioning of the contaminants between the soil and water. The exact location of each sampling station will be established in the field at the time of sampling. The sample station will be noted on a site plan or aerial photograph and marked in the field with flagging and a four-foot long wooden stake. The stake will be labeled with the sample station number and remain in place until completion of the entire project.

If both water and sediment samples are to be collected at a given sampling site, the water samples will be collected prior to the sediment sample. The sediment samples will be collected in the following manner:

1. The sampler will select the sample site, locate it on a site map or aerial photograph and set the wooden stake.
2. Where sediments are to be obtained in wetlands, a grab sample will be obtained in the immediate vicinity of any associated surface water sample. Unless otherwise specified, grab or composited samples will be obtained from the surface of the sediment.

3. The sampler will photograph the sample site (if specified for the project), complete the required records and initiate COC procedures.

Sediment sampling information is recorded on the surface water/sediment field data record form (presented later as Figure 6-8) or may be recorded in a field book.

The recommended sediment collection devices are Teflon or glass coring tubes for shallow wadeable water, and gravity corers in deeper waters. Scoops and drag buckets are not recommended because they cause a great degree of disturbance to the sediment. However, in special applications in deeper water, dredges such as the Eckman and Ponar can be used if precautions are taken to minimize the sediment disturbance.

In shallow, wadeable waters, the direct use of a core liner or tube (five-inch) is recommended. The tube is pushed into the substrate until approximately 1 inch (2.5 centimeters) or less of the tube is above the sediment-water interface. When hard or coarse substrates are sampled, a gentle rotation of the tube while it is pushed will facilitate greater penetration and reduce core compaction. The tube is then capped with a Teflon plug or a sheet of Teflon held in place by a rubber stopper or cork. After capping, the tube is slowly extracted, the negative pressure and adherence of the sediment keeping the sample in the tube. Before the bottom part of the core is pulled above the water surface, it too is capped. Caution should be exercised not to disturb the area to be sampled. The sampler should always stand downstream from the sample location when wading in shallow water.

To help prevent contamination from direct contact between the sampler's hands that the upper part of the tube, a collar-type device is constructed of wood and should have a circular recess to accept the top of the tube. The recess will have a hole in it to allow water to pass through when the tube is pushed in, and will be lined with sheet Teflon. Handles will be attached to the sides of the collar. After the tube is driven in, a wide circular motion will be used to help loosen the core for easy removal; take off the collar device; cap the top of the tube (as described above); pull it up out of the sediment layer; and cap the bottom of the tube before removing it from the water.

Another method of obtaining recently deposited sediments in shallow, wadeable waters with a core tube, is to use the tube as a horizontal scoop. The tube is placed on its side on the sediment surface and carefully inserted into the sediment so that the top inside surface is just at the sediment/water interface. It is important to disturb the fines as little as possible. After the tube is filled, both ends will be capped with a Teflon plug, as described above, before the tube is removed from the sediment. If this method is used with a tube having an outer diameter of 2 inches and wall thickness of 1/8-inch, only the top 2 inches of sediment will be sampled (allowing a 1-millimeter clearance between the sediment surface and top inside of the tube).

A minimum of 500 grams of sediment is collected at each site. Therefore, one tube with a 4-inch-long core, outer diameter of 2 inches, and wall thickness of 1/8 inch is adequate for one sample (the volume of each core would be approximately 750 mℓ). For other tube sizes and core lengths, the number of tubes necessary can be calculated by using the formula for the volume of a cylinder

($\pi r^2 L$). Additional material may be required if duplicate analyses are performed on individual samples.

When the sediment material is difficult to penetrate with a Teflon or glass tube, a commercially available hand coring device can be used. These devices are equipped with a metal barrel, a handle, and a core liner. The liner is inserted and then held in place by a screw-on core cutter, usually manufactured of stainless steel. The core cutter, along with the handle attached to the core barrel, increases the efficiency of sediment penetration. After the sample has been obtained, the cutting head is removed and the liner is carefully withdrawn and immediately capped, as previously described. When coarse grain deposits such as sand are sampled, the use of a core retainer will increase the efficiency of sample retention. Only retainers manufactured of stainless steel should be used in order to minimize the risk of trace metal contamination and eliminate corrosion. When several samples are to be obtained, it is advisable to carry extra core liners to the sample site. This eliminates the need for time-consuming extrusions and permits the use of the core liners as sample containers for shipment to the laboratory.

Substantially different procedures are required to sample sediments in larger streams, lakes or other deep water bodies. Such work is normally accomplished from a raft or boat. If significant thicknesses of sediment must be sampled, test boring techniques will likely be employed.

In deep waters and hard substrates, a gravity corer or thin-wall tube sampler may be required to collect sediment samples. These samplers rely on the weight and gravity to penetrate the bottom.

A gravity corer is easily operated by a two-person crew from a boat or any structure extending over the water surface. The equipment, fastened to a flexible line of rope or wire, is lowered to within 2 or 3 meters of the bottom. Terminal velocity is generally achieved within this distance (Bouma, 1969), and better accuracy and corer orientation is obtained than with a free fall from the surface. The corer is retrieved to the surface, cutting head unscrewed, and liner with sediment removed. Caution must be exercised at this point not to lose the sample, particularly if it is coarse grained. Only those corers that have some water in the core tubes above the sediment should be retained. This ensures that the sediment surface is intact and provides a reference point for determining the sample depth below the sediment/water interface. After the core liner has been removed from the barrel, the bottom and top of the liner should be capped and stored upright in an ice-filled cooler for delivery to the lab. The operation is repeated with a new liner until sufficient samples for sample analysis are obtained.

If both water and sediment samples are to be collected at a given sampling site, the water samples will be collected prior to the sediment sample.

6.7 WATER SAMPLING

6.7.1 General

Water sampling programs are undertaken to define the location, nature and concentration of contaminants in site groundwater, surface water, and/or wastewater. The location and distribution of contaminants at a given site are governed by many factors, including:

- site operation or waste disposal practices;
- site design;
- site closure;
- waste characteristics;
- site topography and surface drainage;
- climate; and
- site hydrogeology.

Development of a water sampling plan that will effectively reveal the distribution and magnitude of contamination at a specific site requires:

- an assessment of the factors listed above;
- evaluation of the methodology and results of any previous sampling and analysis programs which have been completed at the site; and
- definition of the scope and objectives of the project.

Many of the sampling procedures are consistent for all types of water sampling. General considerations are presented here and are discussed in more detail in the following sections.

Sample Collection

Water sample containers are generally filled directly from the source, sampler or pump discharge without special considerations. A major exception is the collection of VOA samples. Volatile Organic Analyte samples must be collected as specified below. Each sample is taken in duplicate.

1. Uncap the sample bottle, taking care not to touch the Teflon-faced septa. If the septa is contaminated in any way, it should be replaced.

2. If a chlorine residual is potentially present, check for chlorine content with KI paper or a chlorine residual comparator. If a residual chlorine content is detected, add three drops of ten (10) percent sodium thiosulfate to the sample container prior to filling the bottle.

3. Fill the sample vial slowly from bailer or pump discharge, minimizing air entrainment, until the vial overflows.

4. Place the Teflon-faced silicon rubber septa on the convex meniscus, Teflon side (shiny side) down and screw cap on.

5. Invert the bottle, tap lightly, and check for air bubbles.

6. If air bubbles are present, open the bottle, add sample to eliminate air bubbles, and reseal. Repeat this procedure until the bottle is filled and no air bubbles are detected.

Sample Preservation

The following preservation procedures are examples of typical preservation protocols specific to the indicated analyses. More detail is provided in Tables 6-1 and 6-2.

Volatile Organic Analytes - Fill the sample bottle as previously described. If chlorine is detected, ten (10) percent sodium thiosulfate should be added (three drops) to the sample container prior to filling the container. Place samples on ice until shipment. Also note that if hold times are anticipated to exceed 7 days, the sample should be preserved with HCl to less than pH 2.*

Semi-volatile Organic Analytes - Fill the sample bottle, seal with a Teflon-lined cap, and place on ice for shipment.

Elements - Following any required filtration, fill the sample bottle, preserve the sample to less than pH 2* with nitric acid, seal container, and place sample on ice for shipment.

Biochemical Oxygen Demand/Residue - Fill sample bottle, seal, and place on ice for shipment.

Chemical Oxygen Demand/Total Organic Carbon/Ammonia - Fill sample bottle as described above, add sulfuric acid until less than pH 2*, cap bottle, and place sample on ice for shipment.

Total Recoverable Phenolics - Fill sample bottle and, if chlorine is present, add one mℓ of ten percent sodium thiosulfate. Add sulfuric acid until pH is less than 2.* Cap sample and place on ice for shipment.

Cyanide - Fill the sample bottle, and if chlorine is present, add one mℓ of ten percent ascorbic acid. Add 10 N sodium hydroxide to a pH greater than 12, cap bottle, and place sample on ice for shipment.

Oil and Grease - Fill sample bottle, add sulfuric acid until pH is less than 2.* Cap bottle, and place sample on ice for shipment.

Disposable pipettes should be used to introduce chemicals into the samples. Chemicals used for preserving should be poured into a 150 mℓ beaker. They should not be drawn directly from the preservative bottles because the bottle may become contaminated. Measurements for pH and temperature should not be taken from the sample containers. When preserving samples, pH paper should be used. The sample should be poured across the pH paper. Never place pH paper directly into sample.

Note: * Shipping regulations limit the amount of preservative which can be added to approximately 1.5 mℓ/1ℓ sample.

6.7.2 Groundwater/Domestic Well Sampling

Objective

To obtain samples of groundwater from new and existing wells suitable for chemical analysis.

Approach

The groundwater sampling locations are selected to delineate the distribution of chemicals and to quantify, to the extent possible, the contaminated groundwater plume in the aquifers underlying the site. The actual sampling points are then selected following review of the locations of the existing groundwater wells (monitoring and domestic) in the vicinity of the site. New monitoring wells may be installed to supplement the existing array. The rationale for their location is normally described in the site work plan.

The sampling locations will be indicated on a site map. Preprinted labels will be prepared for all groundwater samples (using the computerized label system). These samples will consist of various containers for each location and will be analyzed for the parameters selected for the project. A sample splitting flow chart is illustrated in Figure 6-6. The pH and specific conductance of each sample will be determined in the field. Selection of either glass or plastic containers is dependent on the types of analyses that are to be performed. Appropriate containers are specified in Tables 6-1 and 6-2.

6.7.2.1 Monitoring of Groundwater Wells Monitoring of groundwater wells will proceed from the upgradient or background wells to the downgradient or contaminated wells as best as can be determined. The monitoring procedure is as follows:

1. Check the well for proper identification and location.

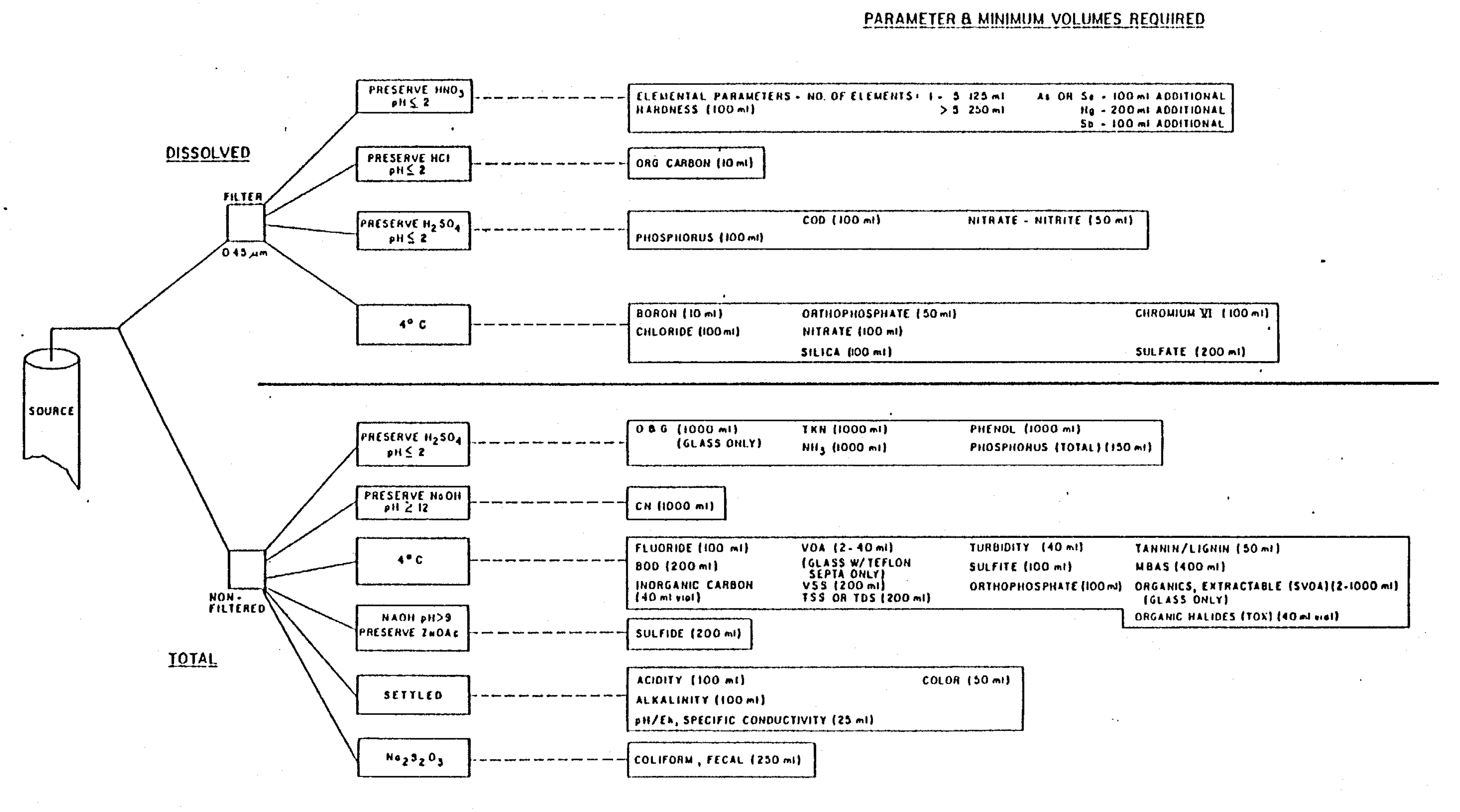
2. Measure and record the height of protective casing.

3. After unlocking the well and removing any well caps, measure and record the ambient and well-mouth organic vapor levels using the photoionization meter. If the ambient air quality at breathing level reaches 5 ppm, the sampler shall utilize the appropriate safety equipment as described in the HASP.

4. Measure and record the distance between the top of the well and the top of the protective casing.

5. Using the electronic water level meter, measure and record the static water level in the well and the depth to the well bottom to the nearest 0.01 foot. Upon removing the water level wire, rinse it with laboratory grade ethanol:methanol 90:10 v/v and then deionized (DI) water.

SAMPLE SPLITTING FLOW CHART–GROUNDWATER/SURFACE WATER MONITORING



NOTE: ALL SAMPLES SHOULD BE KEPT AT 4° C REGARDLESS OF PRESERVATIVE

FIGURE 6–6

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6. Calculate the volume of stagnant water in the well. Volume in liters equals 0.154 times the square of the inside diameter of the well (in inches) times the depth of water (in feet).

6.7.2.2 Sampling of Groundwater Monitoring Wells Following the measurements and calculations described above, sampling will commence in the sequence below.

1. Lower the submersible pump or peristaltic pump intake into the well. For shallow groundwater situations, the intake of the suction tubing or of the submersible pump will be lowered to the top of the water column and the well purged of the required volume. Available alternatives to this procedure may be utilized in certain situations:

2. Connect the instrumentation header to the pump discharge and begin flushing the well. Monitor the in-situ parameters (pH, Eh, temperature, and specific conductivity) and measure the volume of groundwater being pumped. Alternately, in-situ parameters may be monitored in a beaker filled from the pump discharge. Purging of the standing well water is considered complete when the following is achieved:

   - a minimum of three well volumes has been purged, and in situ parameters have stabilized; or
   - five well volumes have been purged; or
   - the well has been pumped dry.

3. Record the in situ parameters.

4. After purging, lower the bailer to the middle of the screened interval or mid-point of the static water level. If the analysis to be performed is for lighter-than-water chemical species, then the bailer should be lowered to the top of the water column for sample collection.

5. Collect the sample(s).

   Volatile and semivolatile samples are filled directly from a bailer with as little agitation as possible.

   Other samples will be placed directly into the appropriate container from the bailer or pump discharge.

   Where filtration is required, an inline filter should be used if possible. Vacuum and pressure filtration are acceptable alternatives to an in-line device. Filtration procedures are described in Table 6-3. Note that all groundwater samples scheduled for analysis of elemental parameters will be filtered, unless specifically prohibited in the task-specific QAPP.

6. Remove the pump or bailer from the well and decontaminate the pump, tubing or bailer by flushing with decontamination fluid specified in Section 6.3. Up to one gallon of the solvent is used as needed.

TABLE 6-3

STANDARD FIELD FILTRATION PROCEDURES

A. IN-LINE FILTRATION

EQUIPMENT

1. A portable 102-mm acrylic backflushing filter unit
2. 102-mm diameter filter papers. 0.45 μm membrane filters
3. DI rinse water
4. 20% v/v nitric acid rinse solution

PROCEDURES

1. Attach in-line filter assembly, after assembling filter paper into filter holder to discharge line of sampling pump. Open by-pass valve completely.

2. Turn sampling pump on slowly, turn by-pass valve closed allowing flow into the filter. Remove trapped air through the filter bleed valve, if necessary.

3. Discard the initial 100 mℓ ± of filtrate. Collect subsequent filtrate into sample bottle.

4. Rinse barrel and filter holder assembly between samples with three rinses of reagent water. The rinse sequence when elemental parameters will be analyzed is: DI water - 20% v/v nitric acid - DI water.

TABLE 6-3 (Continued)

STANDARD FIELD FILTRATION PROCEDURES

B. VACUUM FILTRATION

EQUIPMENT

1. Two sets of either glass funnel type of self-contained polysulfone filters with sintered glass discs or polysulfone filter plates
2. 47-mm diameter filter papers, 0.45 μm membrane filters
3. Vacuum pump or ISCO peristaltic pump with silicone tubing
4. DI rinse water
5. 20% v/v nitric acid rinse solution

PROCEDURES

1. Thoroughly rinse sintered glass disc, filter funnel, and stem or polysulfone filter units with DI water.
2. On the basis of visual clarity of sample, prefiltering with larger pore filters may be required. If sample has a heavy clay content, organics, or suspended matter, prefiltration through a 3.0 or 5.0-μm membrane filter may be necessary.
3. Place membrane filter on filter holder with minimum handling.
4. Attach filter holder with filter to filter funnel and receiver.
5. Swirl and slowly pour sample bottle into filter funnel.
6. Attach suction tubing to filter flask and vacuum pump (or ISCO pump). Pump is tuned on in the vacuum mode.
7. Filter a small portion of the sample and discard filtrate after rinsing flask with sample filtrate.
8. If prefiltering was required, pass sample through a 0.45-μm membrane filter using another filtering apparatus.
9. Transfer filter sample to appropriate bottles.
10. Rinse filtration equipment between samples with at least three rinses of DI water. The rinse sequence, when elemental parameters are to be analyzed, is: DI water - 20% v/v nitric acid - DI water.

TABLE 6-3 (Continued)

STANDARD FIELD FILTRATION PROCEDURES

C. PRESSURE FILTRATION

EQUIPMENT

1. Pressure filter apparatus consisting of 1 liter barrel filter, filter holder, and pressure hose connectors.

2. Source of pressurized gas, i.e., tank of nitrogen, argon, etc.

3. 147 mm filter papers, 0.45-μm membrane filter.

4. Place filter holder and filter onto barrel assembly, making sure to align O-ring for a positive seal.

5. Attach swing-away bolts and tighten hand-tight.

6. Turn over filter assembly and attach pressure hose assembly.

7. Slowly turn on pressurized gas and increase pressure regulator to a maximum of 20 psi.

8. Collect filtrate from bottom of barrel assembly.

9. Rinse barrel and filter holder assembly between samples with three rinses of DI water. The rinse sequence when elemental parameters will be determined is: DI water - 20% v/v nitric acid - DI water.

Rinse the bailer with one gallon of potable or DI water. Rinse again with potable or DI water.

7. Complete sample data record (Figure 6-7) after each well is sampled.

8. Secure the well cap and lock.

Domestic Wells. Domestic water supply wells will be sampled in a similar manner, with the exception of using the in-place pumping equipment. The sampling point will be determined at the time of sampling, and will be as close to the pump as practical at each location. Domestic supply samples will not be taken from taps delivering aerated, softened or filtered water. Faucet aerators will be removed if possible before sampling. The water tap will be turned on and run for at least 5 minutes before the sample is taken to flush stagnant water from the system. All sample containers will be filled with water directly from the tap and the samples processed as described for monitoring well samples except that samples collected for elemental parameters will not be filtered so that the sample will represent actual ingestion. Components of the plumbing system will be noted to assist in data interpretation.

6.7.3 Surface Water

Objective

To obtain surface water samples, commonly referred to as ambient water samples, to characterize the physical and/or chemical status relative to a pristine condition, and to establish the degree and extent of contamination.

Approach

The technique for surface water sampling must be selected after addressing such items as:

- depth of water body;
- flow rate;
- stratification;
- specific gravity/solubility of anticipated analytical parameters;
- seasonal variations; and
- analytical parameters of interest.

The sample will be taken in the following manner:

1. Collect the sample from the surface water body by immersing a clean beaker or the sample bottle. If a stream is being sampled, collect the sample upstream of the sampler with the opening of the sampling device oriented upstream but avoiding floating debris.

2. Directly fill the appropriate sample containers from the sampling device if needed.

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GROUNDWATER FIELD SAMPLE DATA RECORD

PROJECT ____________________ JOB NO __________

STATION NO/LOCATION ____________________ DATE __________

SKETCH ON BACK YES ☐ NO ☐ PHOTOGRAPHS YES ☐ NO ☐ ROLL NO/EXPOSURE NO ______

FIELD DATA

TIME: START ______ END ______ AIR TEMP ______ WEATHER ______

WATER DEPTH ______ ☐ TOP WELL ☐ TOP CASING WELL DEPTH ______ WELL DIAM. ______ WELL MATERIAL ______

WELL STICK-UP ______ WELL/CASING ______

SAMPLING EQUIPMENT USED ______ VOLUME PURGED ______

FIELD DATA COLLECTION ☐ IN SITU ☐ IN BOTTLE

VOA LEVEL(PPM) AMBIENT ______ SAMPLE LOCATION ______ HEADSPACE ______

SAMPLE PURGE DATA

@ ______ GAL | @ ______ GAL | @ ______ GAL | @ ______ GAL

TEMP ______ °C | TEMP ______ °C | TEMP ______ °C | TEMP ______ °C

SP. COND ______ @25°C | SP. COND ______ @25°C | SP. COND ______ @25°C | SP. COND ______ @25°C

pH ______ | pH ______ | pH ______ | pH ______

Eh ______ | Eh ______ | Eh ______ | Eh ______

BOTTLE ID	LAB ID	VOL	MATERIAL	FILTERED	PRES./VOL.	ANALYSIS REQUESTED

REMARKS/OBSERVATIONS ____________________

SAMPLER ____________________

FIGURE 6-,

3. Measure the following parameters, if possible, by direct immersion of instrument probes into the water body:

   - photoionization meter reading;
   - temperature measurement;
   - pH measurement;
   - specific conductance measurement; and
   - any other site-specific field measurements required.

   If direct measurement is not possible, measure these parameters from water remaining in the sampling device or another sample bottle. This information will be recorded on the sample data record, sample labels will be completed and chain-of-custody procedures will be initiated.

4. Complete the sample data record (Figure 6-8).

Surface water samples may also be composited over time, as described in Section 6.7.4.

6.7.4 Wastewater

Objective

The objective of wastewater discharge sampling, commonly referred to as source sampling, is to characterize a treated, untreated or partially treated waste stream in terms of flow rate, volume, chemical constituents and physical properties. Source sampling is employed in treatability studies, regulated effluent compliance determination, process control and identification of potential contributors to a contamination incident. It often requires 24-hour composite sample collection, continuously for multiple 24-hour periods.

Approach

Based on existing data, or during initial site reconnaissance, sampling locations will be selected in accordance with project goals, i.e. to procure a sample which appropriately represents the properties being investigated. Special emphasis is required prior to sampling to accurately define the goals of sampling and assess the impact of sampling methodologies on analytical requirements and the intended use of analytical results. The need to measure the flow rate of the stream and the accuracy required must also be assessed in light of project goals. In many cases, very accurate flow monitors may exist, or must be installed by the sampling crews. However, in certain instances, only knowledge of total volume is required. In any case, this aspect of source sampling must be integral to the selection of sampling technique.

ECJORDANCO

SURFACE WATER /SEDIMENT FIELD SAMPLE DATA RECORD

PROJECT ______ JOB NO ______

STATION NO/LOCATION ______ DATE ______

SKETCH ON BACK YES ☐ NO ☐ PHOTOGRAPHS YES ☐ NO ☐ ROLL NO/EXPOSURE NO ______

FIELD DATA

TIME: START ______ AIR TEMP. ______

END ______ WEATHER ______

WATER DEPTH @ SAMPLE LOCATION ______ WIDTH OF STREAM ______

TYPE OF STREAM SAMPLE ______ SAMPLE METHOD ______

STREAM VELOCITY MEASUREMENTS ☐ YES ☐ NO

FIELD DATA COLLECTED ☐ IN SITU TEMP ______ °C

☐ IN BOTTLE SP. COND ______ a 25°C pH ______

DISSOLVED OXYGEN ______ PPM ☐ METER VOA LEVEL(PPM) AMBIENT ______

☐ WINKLER SAMPLE LOCATION ______

HEADSPACE ______

TYPE/DESCRIPTION OF SEDIMENT ______

DEPTH OF SEDIMENT SAMPLE ______ EQUIPMENT USED ______

BOTTLE ID	LAB ID	VOL	MATERIAL	FILTERED	PRES./VOL.	ANALYSIS REQUESTED

REMARKS/OBSERVATIONS ______

SAMPLER ______

FIGURE 6-8

Sampling Location. Sampling locations will be chosen to provide the most representative sample (e.g. if two outfalls are present, sample in the stream just below where the water is mixed). Samples will be taken in the center of the channel where the flow and mixing is greatest, and never near the end of a dead end piping line. The techniques (e.g., depth of sampling, method of sampling) will be uniform among the samples procured within a given facility or area to the extent possible.

Sampling Procedures

Automatic Composites. Conditions permitting, automatic composite samplers (ISCO 1580 super-speed) will be set up at each sample location. Constant time - constant volume samples will normally be collected. The following is the procedure for the composite sampler set-up:

1. Transport the composite samplers to the sampling points.

2. Place sampler such that suction line is as short as possible. Use AC power whenever possible.

3. Place silicon tubing in sampler and cut Teflon suction line to desired length. Insert Teflon tubing into silicon tubing and secure with hose clamps.

4. Collect sampler blank according to blank procedures.

5. Secure the sampler tubing to obtain a representative sample. Rigid conduit or stainless steel weights should be used to secure the tubing so that it is facing into the waste stream. The intake line should be situated at a turbulent location and at a depth between 1/3 and 1/2 the channel depth. The Teflon tubing must extend beyond the rigid conduit.

6. Calibrate the composite samplers with a graduated beaker. Aliquot volumes for a 24-hour composite with a 20-minute interval between samples are as follows:

   130 mℓ/20 minutes for a 2.5 gallon composite
   160 mℓ/20 minutes for a 3.0 gallon composite
   260 mℓ/20 minutes for a 5.0 gallon composite

   (See ISCO manual for sampler instructions.)

7. Place appropriate sampler jug in the base of the sampler. Pack ice around sampler container.

8. Remove cap and Teflon liner from sample jar and place in a secure place.

9. Secure ISCO control unit to the sampler base (a cylindrical sampler extension neck will be necessary when a five-gallon jug is used).

10. Monitor the first sample aliquot to ensure proper operation.

11. Check the composite sampler at least every four hours to ensure that it is operating properly and adequately iced. Spent desiccant should be replaced with dry desiccant when necessary.

12. If improper volumes of sample are noted, take necessary steps to correct sampler malfunction. If the sampler is pulling too little sample, increase the sample aliquot volume or decrease the time between sample intervals. If the sampler is pulling too much sample, stir the composite, discharge the excess and recalibrate the ISCO to draw the appropriate volume.

13. Allow composite sampler to run for 24 hours.

14. Replace composite container with a clean jug at the end of each 24-hour period.

15. Replace the silicon and Teflon tubing with new tubing at the completion of each 72-hour period. Sampler blanks must be run every time the tubing is changed.

Manual Composites. In certain instances, manual compositing will be required. Sludge locations with a high solids content, pressurized discharge lines, and inaccessible sample locations are a few examples that require manual compositing. The following procedures should be used:

1. Determine the desired volume and frequency of sample aliquots.

2. Procure sample. If a discharge line is used, be sure to clear line of any debris, etc. so that a fresh, uniform sample is obtained. If aliquots are drawn from a wet well, manhole, or other location by means of an intermediate container, be sure to thoroughly rinse the container prior to drawing sample.

3. Repeat Step 2 at the appropriate intervals until the desired volumes have been collected and composited in the appropriate container. The composite container should be iced at all times.

Grab Samples. In situ measurements for pH and temperature will be taken concurrent with grab samples. Grab samples will be taken according to the following procedure:

1. Determine the time interval at which samples will be collected.

2. Identify any sample locations at which a chlorine residual is present.

3. Collect the appropriate samples. The preferred method for grab sampling is immersion of the sample bottle or appropriate beaker in the waste stream. The container should be thoroughly rinsed with sample and then filled. Samples should be taken from a turbulent section of the waste stream at a depth of one-third to one-half the stream depth to ensure a well-mixed, representative sample. If the

physical characteristics of the sample point prevent this, samples may be collected through the ISCO pump unit. Before doing this, purge the suction line (switch to reverse) then run (switch to forward) until the pump discharge is uniform. Bottles may be filled directly from the pump discharge. In the event that neither procedure is appropriate, samples may be collected by means of a stainless steel bucket. Should this be necessary, the bucket must be thoroughly rinsed with the wastewater prior to sample collection.

Sample Handling

The procedures for handling the listed sample fractions are described in the following sections:

Composite Samples. Samples for SVOA, Inorganics, Biochemical Oxygen Demand (BOD)/Residue, and Chemical Oxygen Demand (COD)/Total Organic Carbon (TOC)/ammonia analyses are all taken from the sample composite container. The composite sample must be blended to provide a homogeneous mixture, including a representative suspension of any solids in the container. No specific method is required; hand stirring with clean glass rods or mechanical stirring with paddles that are Teflon-coated is acceptable. Metal mixing devices may not be used.

General steps for splitting a composite sample are:

1. Line up all appropriate bottles into which the sample must be poured (COD/TOC/ammonia, BOD/Residue, SVOA and elements.

2. Blend the sample and sequentially fill each sample bottle one-third full.

3. Gently swirl the composite, return to the first bottle, fill an additional one-third of each bottle.

4. Repeat the same pattern and fill the last one-third of each.

5. Leave some head space so that any preservative chemicals required may be added. Preservation requirements are described in Section 6.7.1 and Tables 6-1 and 6-2.

6. If appropriate, record data on the Field Sample Data Sheet (Figure 6-9).

Grab Samples. VOA, cyanide, oil and grease, and total recoverable phenolics samples are taken as grab samples in the field. These samples may be composited in the lab. The waste streams must be tested for the presence of chlorine. Potassium iodide starch paper can be used to detect a chlorine residual. If plant personnel suspect a chlorine residual and the KI test is negative, it should be assumed that chlorine is present. Preserve the grab samples as described in Section 6.7.1.

FIELD SAMPLE DATA SHEET

PLANT ____________________

CREW ____________________ CHI

SAMPLE TYPE															SAMPLE NUMBER	PRESERVATIVE		DATE			COMPOSITE ENDING DATE			TEMP °C	pH @ POINT OF SAMPLING	RCDR'S INITIALS	SAMPLING POINT DESCRIPTION	NOTES:
OIL & GREASE	[illegible]	SULFIDES	TOTAL [illegible]	TOTAL PHENOL	SAMPLE BL	VOL ORG BL	VOL ORG	MERCURY	CYANIDE	BOD/TSS	NON-VOL ORG	METALS	ASBESTOS	COD/TOC/TKN/NH3		[illegible]	CHEMICAL	MONTH	DAY	TIME	MONTH	DAY	TIME					

FIGURE 6-

6.8 SOIL GAS

Soil gas samples are collected from the vadose zone to assist in contaminant source location. Jordan may subcontract both sampling and analysis for this task on a site-specific basis. Organizational details will appear in each site's Work Plan. Jordan's procedure is described below. Subcontractor procedures will be included in site QAPP Addenda.

6.8.1 General Soil Gas Procedures

Soil gas surveys are used to help identify and characterize the extent of subsurface contamination. Soil gas just below the surface is analyzed for volatile organic compounds (VOCs) present in the soil or migrating upward from deeper contamination. The main advantage of this method is that large areas can be investigated at a lower cost than drilling or test pitting.

The soil gas sample can be obtained using a variety of methods. A probe is driven into the ground to a depth determined by site-specific hydrogeologic conditions. This probe can be a modified split spoon apparatus, a slide bar, or a hollow probe inserted after augering. Once the probe is in place, Teflon tubing is connected to a pump drawing 100-150 mℓ/min. An air tight syringe pierces the Teflon tubing to remove the gas sample. The sample is then injected into the field gas chromatograph (Photovac 10 series or equivalent) to determine the absence or presence of target VOCs. Cross-contamination in the sampling procedure is avoided by changing the Teflon tubing and thorough decontamination of the probes between samples.

A number of gas chromatographs can be used that meet the portability and sensitivity requirements. E.C. Jordan will use a Photovac 10S50 equipped with a photoionization detector (PID) unless otherwise noted. A Teflon column and precolumn packed with 5% SE-30 is used for separation. The column length will be left to the analyst's discretion. Target compounds usually include benzene, toluene, trans-1,2-dichloroethane (t-1,2-DCE), trichloroethylene (TCE), and perchloroethylene (PCE). A three-point calibration curve will be run for target compounds. Quality control will consist of method blanks, syringe blanks, and duplicates.

6.9 HYDROCARBON SCREEN FOR SOIL/SEDIMENT AND WATER SAMPLES

6.9.1 Scope and Application

This is a heated headspace capillary GC-PID/FID (in series) method applicable to the determination of hydrocarbons (i.e. gasoline, fuel oil) in soil/sediment and water samples.

The estimated method detection limit (MDL) for each parameter in water is as follows:

	$\mu g/\ell$
gasoline	10
fuel oil	50
hexane	10
benzene	10
toluene	10
xylenes	10
methy t-butyl ether (MTBE)	20

The MDL for soil/sediment samples may differ from those listed, depending upon the nature of chemical interferences in the sample matrix.

6.9.2 Summary of Method

An inert gas (helium) is bubbled through a 5 ml water sample or 5 g soil sample (in 5 ml of water) contained in a specially designed purging chamber at 65°C. The compounds of interest are transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbent trap where the compounds are trapped. After purging is completed, the trap is heated and back flushed with the inert gas to desorb the compounds on to a gas chromatographic column (DB-5). The gas chromatograph is temperature programmed to separate the compounds which are detected with a photoionization detector and a flame ionization detector in series.

7.0 SAMPLE CUSTODY

7.1 GENERAL

Jordan has established a program of sample chain-of-custody (COC) that is followed during sample handling activities in both field and laboratory operations. This program is designed to assure that each sample is accounted for at all times. To maintain this level of sample monitoring, computer-generated sample container labels and shipping manifests are normally employed. Field data sheets, COC records, and analytical request forms (ARF) must also be completed by the appropriate sampling and laboratory personnel for each sample.

The objective of the Jordan sample custody identification and control system is to assure, to the extent practicable, that:

- all samples scheduled for collection, as appropriate for the data required, are uniquely identified;
- the correct samples are analyzed and are traceable to their records;
- important sample characteristics are preserved;
- samples are protected from loss or damage;
- any alteration of samples (e.g., filtration, preservation) is documented;
- a forensic record of sample integrity is established; and
- client confidentiality is maintained.

The advantages of a computer-based COC system over field marking systems are:

- all required samples are indicated on pre-prepared labels and shipping manifests; and
- once the computer-generated label is affixed to the bottle and covered with clear plastic tape, sample identification is virtually unalterable without evidence.

The COC protocol followed by the sampling crews involves:

- Documenting procedures and amounts of reagents or supplies (e.g., filters) which become an integral part of the sample from sample preparation and preservation.
- Recording sampling locations, sample bottle identification, and specific sample acquisition measures on the appropriate forms.
- Using pre-prepared sample labels to document all information necessary for effective sample tracking.
- Completing standard field data record forms to establish sample custody in the field before sample shipment (see Section 6).

Pre-prepared labels are normally developed for each sample to be collected. Each label is numbered to correspond with the appropriate sample(s) to be collected. A summary of the labels prepared, with space for sample tracking and notations, is also printed. This sample manifest assists sample control in the field and is eventually retained as part of the project file. Examples of pre-prepared labels and sample manifests are shown in Figures 7-1 and 7-2.

The COC record is used to:

- document sample handling procedures including sample location, sample number and number of containers corresponding to each sample number;
- document the sample; and
- document the COC process.

The COC description section requires:

- the sample number and sample bottle identification number, where applicable;
- the names of the sampler(s) and the person shipping the samples;
- the date and time that the samples were delivered for shipping; and
- the names of those responsible for receiving the samples at the laboratory.

A COC record is shown in Figure 7-3.

The COC record is completed in quadruplicate. Two copies accompany the samples to the laboratory, another is kept by the sample crew chief and transferred to the Laboratory Services Coordinator (LSC) and the last copy is maintained in the project file. Additional copies can be provided if needed for the project.

7.2 SAMPLE SHIPMENTS

Packing

Sample containers are generally packed in picnic coolers for shipment. Bottles are to be packed tightly so that no motion is possible. Styrofoam, vermiculite, and "bubble pack" are suitable for most instances. (High-hazard samples require different packing.) Ice is placed in double "Ziploc" bags and added to the cooler along with all paperwork in a separate "Ziploc" bag. The cooler top is then taped shut. Custody seals and taping of bottle caps may be required for certain samples, particularly those analyzed through the USEPA Contract Laboratory Program.

E.C. JORDAN CO. 1300-82
DATE TIME
MW-101
VOA-624
40ML NO FILT 4 DEG.C
100

E.C. JORDAN CO. 1300-82
DATE TIME
MW-101
VOA-624
40ML NO FILT 4 DEG.C
101

E.C. JORDAN CO. 1300-82
DATE TIME
MW-101
EXT ORG-625
1-LITER NO FILT 4 DEG.C
102

E.C. JORDAN CO. 1300-82
DATE TIME
MW-101
EXT ORG-625
1-LITER NO FILT 4 DEG.C
103

E.C. JORDAN CO. 1300-82
DATE TIME
MW-101
DISSOLVED ORG. CARBON
60ML FILTERED HCL
104

E.C. JORDAN CO. 1300-82
DATE TIME
MW-101
DISS:FE/CU/CD/MN
250ML FILTERED HNO3
105

E.C. JORDAN CO. 1300-82
DATE TIME
MW-102
VOA-624
40ML NO FILT 4 DEG.C
106

E.C. JORDAN CO. 1300-82
DATE TIME
MW-102
VOA-624
40ML NO FILT 4 DEG.C
107

E.C. JORDAN CO. 1300-82
DATE TIME
MW-102
EXT ORG-625
1-LITER NO FILT 4 DEG.C
108

E.C. JORDAN CO. 1300-82
DATE TIME
MW-102
EXT ORG-625
1-LITER NO FILT 4 DEG.C
109

E.C. JORDAN CO. 1300-82
DATE TIME
MW-102
DISSOLVED ORG. CARBON
60ML FILTERED HCL
110

E.C. JORDAN CO. 1300-82
DATE TIME
MW-102
DISS:FE/CU/CD/MN
250ML FILTERED HNO3
111

E.C. JORDAN CO. 1300-82
DATE TIME
MW-103
VOA-624
40ML NO FILT 4 DEG.C
112

E.C. JORDAN CO. 1300-82
DATE TIME
MW-103
VOA-624
40ML NO FILT 4 DEG.C
113

E.C. JORDAN CO. 1300-82
DATE TIME
MW-103
EXT ORG-625
1-LITER NO FILT 4 DEG.C
114

E.C. JORDAN CO. 1300-82
DATE TIME
MW-103
EXT ORG-625
1-LITER NO FILT 4 DEG.C
115

E.C. JORDAN CO. 1300-82
DATE TIME
MW-103
DISSOLVED ORG. CARBON
60ML FILTERED HCL
116

E.C. JORDAN CO. 1300-82
DATE TIME
MW-103
DISS:FE/CU/CD/MN
250ML FILTERED HNO3
117

E.C. JORDAN CO. 1300-82
DATE TIME
MW-104
VOA-624
40ML NO FILT 4 DEG.C
118

E.C. JORDAN CO. 1300-82
DATE TIME
MW-104
VOA-624
40ML NO FILT 4 DEG.C
119

E.C. JORDAN CO. 1300-82
DATE TIME
MW-104
EXT ORG-625
1-LITER NO FILT 4 DEG.C
120

E.C. JORDAN CO. 1300-82
DATE TIME
MW-104
EXT ORG-625
1-LITER NO FILT 4 DEG.C
121

E.C. JORDAN CO. 1300-82
DATE TIME
MW-104
DISSOLVED ORG. CARBON
60ML FILTERED HCL
122

E.C. JORDAN CO. 1300-82
DATE TIME
MW-104
DISS:FE/CU/CD/MN
250ML FILTERED HNO3
123

FIGURE 7-1
EXAMPLE COMPUTERIZED LABLES
E.C. JORDAN CO.

DATE: TIME:

SAMPLE ID	CLIENT ID	NOTES	PARAMETER		CONTAINER	PRESERVED	ECJ SERIAL	DATE SAMPLED
MW-101	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	100	
MW-101	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	101	
MW-101	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	102	
MW-101	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	103	
MW-101	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	104	
MW-101	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	105	
MW-102	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	106	
MW-102	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	107	
MW-102	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	108	
MW-102	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	109	
MW-102	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	110	
MW-102	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	111	
MW-103	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	112	
MW-103	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	113	
MW-103	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	114	
MW-103	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	115	
MW-103	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	116	
MW-103	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	117	
MW-104	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	118	
MW-104	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	119	
MW-104	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	120	
MW-104	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	121	
MW-104	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	122	
MW-104	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT.	250 ML.	HNO3	123	
MW-105	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	124	
MW-105	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	125	
MW-105	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	126	
MW-105	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	127	
MW-105	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	128	
MW-105	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	129	
SW-4	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	130	
SW-4	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	131	
SW-4	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	132	
SW-4	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	133	
SW-4	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	134	
SW-4	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	135	
SW-5	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	136	
SW-5	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	137	
SW-5	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	138	
SW-5	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	139	
SW-5	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	140	
SW-5	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	141	
SW-6	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	142	
SW-6	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	143	
SW-6	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	144	
SW-6	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	145	
SW-6	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	146	
SW-6	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	147	
DUPLICATE-1	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	148	
DUPLICATE-1	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	149	
DUPLICATE-1	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	150	
DUPLICATE-1	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	151	
DUPLICATE-1	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	152	
DUPLICATE-1	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	153	
DUPLICATE-2	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	154	
DUPLICATE-2	E.C.JORDAN CO.		VOLATILE ORG.#624		40 ML.	4 DEG.C	155	
DUPLICATE-2	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	156	
DUPLICATE-2	E.C.JORDAN CO.		EXT. ORGANICS#625		1000 ML.	4 DEG.C	157	
DUPLICATE-2	E.C.JORDAN CO.		DISSOLVED ORG. CARBON	FILT	60 ML	HCL	158	
DUPLICATE-2	E.C.JORDAN CO.		DIS. FE/CU/CD/MN	FILT	250 ML.	HNO3	159	

FIGURE 7-2
EXAMPLE SAMPLE M IFEST

PAGE ___ OF ___

CHAIN OF CUSTODY RECORD

PROJECT NO.	PROJECT NAME					NO. OF CONTAINERS	SAMPLE TYPE												REMARKS
SAMPLERS (SIGNATURE)																			
STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION														INDICATE SOIL/WATER/AIR SEDIMENT/SLUDGE

RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)
RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)
RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED FOR DISPOSAL BY: (SIGNATURE)	DATE / TIME	REMARKS	

FIGURE 7-3

Shipping

The standard procedure followed for shipping environmental samples to the analytical laboratory is:

1. All shipping of environmental samples collected by Jordan personnel must be done through Federal Express or equivalent overnight delivery service.

2. Prior to leaving for the field, the person responsible for sample collection must notify the LSC of the number, type and approximate collection and shipment dates for the samples. If the number, type or date of shipment changes due to site constraints or program changes, the task leader must notify the LSC of the changes. This notification from the field also needs to occur when sample shipments will arrive on Saturdays. The LSC will coordinate sample pick-up with the laboratory.

3. If prompt shipping and laboratory receipt of the samples cannot be guaranteed (i.e. Sunday arrival), the samplers will be responsible for proper storage of the samples until adequate transportation arrangements can be made.

4. Project Managers must notify the LSC when samples collected by clients are going to be shipped to the laboratory.

The LSC keeps the laboratory informed of all field sampling activities. This communication is critical to allow the laboratory enough time to prepare for the samples' arrival.

The samples are shipped to the laboratory together with the COC documents, and the ARF.

Figure 7-4 is an example sample tracking form. This form provides the initial information the LSC requires. The laboratory is notified from the field by telephone of shipment. Sample collection and shipment documentation are sent to the LSC. Sample receipt log, COC and ARF are returned to the LSC by the laboratory.

Due to the nature of the IRP, additional sample/data tracking procedures are employed. The procedure described below allows each TD to verify receipt of analytical data for his Task's samples and provides a dynamic means for assessing the status of a sampling/analysis event. The tracking report also provides a cross reference between field sample identification and laboratory sample identification.

SAMPLE TRACKING FORM

SAMPLE SITE NAME/CODE: ______________________________

____

TASK NO. ______________________________

E.C. JORDAN JOB NO. ______________________________

SAMPLING PERSONNEL: ______________________________

DATE SAMPLED	DATE SHIPPED	ECJ SAMPLE LOCATION	TYPE OF (1) SAMPLE	E.P.A. TRAFFIC REPORT NO	ANALYTICAL LABORATORY	REQUIRED ANALYSIS (2)								
						VOA	BNA	PEST PCB	METALS					

COMMENTS: ______________________________

(1) SW - SURFACE WATER
GW - GROUNDWATER
S - SOLIDS
L - LEACHATE
M - MIXED MEDIA
O - OTHER

(2) TOP HALF OF BOX = PROPOSED ANALYSIS
BOTTOM HALF OF BOX = ANALYSIS ACTUALLY REQUESTED

FIGURE 7-4

7.3 DATA TRACKING & HANDLING

7.3.1 Data Tracking

1. Prior to initiating a sampling episode, create a task-specific Sample Tracking Form (Figure 7-4). Enter the E.C. Jordan sample location, type sample (media), and then place an "X" in the top half of each square of the column for which an analysis is proposed. Copy the resulting tracking form, along with projected sampling dates and name of analytical laboratory, and send it to the LSC. The LSC will then contact the analytical laboratory and pass on the above information.

2. While the sampling episode is underway, complete the task-specific Sample Tracking Form based on the chain-of-custody records. Enter the date sampled, date shipped, analytical laboratory, airbill number, and then place an "x" in the bottom half of each square in the column for which an analysis is actually requested. When entering field duplicates, identify it with a sample identifier plus a "D", i.e., MW-101D. If a replicate sample is sent to a second laboratory, identify it with a sample identifier plus a "R", i.e., MW-101R. Identify the second laboratory in the appropriate column. Send a copy of the resulting tracking form, along with a copy of all COCs and ARFs, to the LSC at the completion of the sampling episode.

3. The LSC will maintain an electronic sample tracking database. In addition to the information contained in the sample Tracking Form, the data base will keep track of when the data results are due, sample status, and any problems or changes encountered by the analytical laboratory. As analytical data are received from the laboratory, the samples will be logged in as "Analyses Received" in the sample tracking database. Results will then be forwarded to the Project Manager and stored in a task-specific trans-file.

7.3.2 Data Handling

1. Create a task-specific analytical data file. Be sure to modify the parameter list as appropriate for your particular investigation.

2. Enter the data:
   - Include all data modifiers, i.e. "B", "J" or brackets.
   - Do <u>not</u> enter any data not generated by Jordan without specific authorization from the QAO.
   - Enter all 'Tentatively Identified Compounds' with a spectral match greater than 90 percent.
   - Do <u>not</u> separate data packages unless a copy of the data package cover letter is attached to all parts of the package.

3. Check the data entered for accuracy and completeness.

4. Update the data tracking form as described in Data Tracking #3 above.

8.0 CALIBRATION PROCEDURES AND FREQUENCY

8.1 CALIBRATION PROCEDURES FOR LABORATORY EQUIPMENT

These procedures are described in the Standard Operating Procedures prepared by the participating laboratory submitted separately.

8.2 CALIBRATION PROCEDURES AND FREQUENCY FOR FIELD INSTRUMENTS

Each piece of equipment will be calibrated prior to each day's use. Data is recorded on the form shown as Figure 8-1. The procedures described below apply to the specific instrument noted. If other instruments are used, the manufacturer's calibration procedures are followed.

8.2.1 Y.S.I. S-C-T Meter (Model No. 33)

Temperature Probe.

1. Using a National Bureau of Standards-approved thermometer, immerse both probes into a beaker of water and note any differences for the field probe.

2. Recalibrate as necessary.

Specific Conductance Meter.

1. Calibrate meter and probe using the calibration control and the red-line on the meter dial (Y.S.I. S-C-T Meter, Model No. 33).

2. Turn the function switch to read conductivity x 10 and then depress the cell test button, noting the deflection. If the needle falls more than 2 percent of the reading, clean the probe and retest.

3. Using at least two buffer solutions, which will most likely bracket the expected values for conductivity, note accuracy of the water and probe and clean probe if necessary.

8.2.2 Specific Ion Meter

pH Probe.

1. Place electrodes and buffer solutions in a water bath at the temperature of the water to be sampled. After temperature equilibrium, measure temperature and adjust the temperature compensation knob for this temperature.

2. If using refillable probes, remove electrode cap and check that filling solution is above the filling mark.

E.C.JORDAN CO. PAGE ______ OF ______

FIELD INSTRUMENTATION QUALITY ASSURANCE RECORD

PROJECT ______________________ DATE ______________

JOB NO ______________

CALIBRATION DATA

EQUIPMENT I.D. ______________________

ELECTRICAL, BATTERY VOLTAGE: ☐ OK ☐ REPLACE

TEMPERATURE PROBE CALIBRATED: ☐ YES ☐ NO DATE OF LAST CALIBRATION ______________

SPECIFIC CONDUCTIVITY PROBE/METER CALIBRATION:

CONDUCTIVITY STANDARD ________ µmhos/cm ________ METER READING

________ µmhos/cm ________ METER READING

________ µmhos/cm ________ METER READING

pH/Eh PROBE CALIBRATION pH BUFFER ____ 4 ____ 7 ____ 10

Eh MILLIVOLT ____ 4 ____ 7 ____ 10

DISSOLVED OXYGEN METER CALIBRATION ______________

WINKLER CALIBRATION

AVERAGE WINKLER TITRATION VALUE ________ PPM METER CORRECTION ☐ YES ☐

OTHER: ______________________

____

SAMPLING EQUIPMENT/DECONTAMINATION RECORD

SAMPLING EQUIPMENT USED: ☐ ELECTRIC SUBMERSIBLE PUMP ☐ PERISTALTIC PUMP ☐ GRAVITY CORER

☐ BLADDER SUBMERSIBLE PUMP ☐ TEFLON/S.S. BAILER ☐ ______________

☐ ______________

DECONTAMINATION FLUIDS USED: ☐ DISTILLED WATER ☐ METHANOL ☐ ______________

☐ ISOPROPANOL ☐ TCP ☐ ______________

FILTRATION EQUIPMENT USED: ☐ VACUUM FILTRATION ACID-RINSED: ☐ YES ☐ NO

☐ PRESSURE FILTRATION FILTRATION BLANK PREPARED: ☐ YES ☐ NO

SAMPLER ______________________

FIGURE

3. Immerse the probe in the pH 7 buffer solution and adjust the calibration control to read the appropriate pH. Check the pH buffer solution for correct pH value at the equilibrated temperature.

4. Remove the probe, rinse with distilled water and then immerse in either the pH 4 or pH 10 buffer solution, depending on the expected pH of the sample.

5. If the meter does not register the correct pH for that buffer solution, adjust the calibration knob on the back of the instrument to obtain the pH of the buffer.

6. After rinsing, insert the pH probe into the flow cell and allow the probe to come to equilibrium with the sample water.

7. The pH probe is stored in the ambient air overnight.

Eh Probe.

1. Check that the platinum probe is clean and the platinum band or tip is unoxidized. If dirty, polish with emery paper.

2. Immerse the standard solution, Zobell solution, and probe in a water bath at the temperature of the water to be sampled. After the temperature has equilibrated, immerse the probe and the reference probe, if required, into the Zobell solution. Record the mV reading and the temperature and compare with the expected value (±10-20 mV).

3. Rinse the probe with distilled water or probes and insert into the flow cell. Allow for temperature equilibration and record the sample Eh.

4. At the end of the day, the probes should be stored in water.

8.2.3 Tripar Analyzer

Temperature Calibration.

Temperature Zero Adjustment - Connect the temperature sensor and select temperature as the display parameter. Remove the rear access cover exposing the sensor calibration potentiometers.

Prepare an ice water slurry and place the temperature sensor in the solution. Allow the temperature sensor to stabilize for approximately one minute while stirring the sensor in the solution vigorously. Using the adjustment tool provided in the rear cover, adjust the temperature "zero" potentiometer for a reading of 0.00°C on the system display.

Temperature Span Adjustment - Prepare a test solution to be used for temperature calibration. A beaker of water at room temperature works well as it will not be changing rapidly in temperature. Place the Tripar temperature sensor in the test solution and allow to stabilize for approximately one minute. Using a precision laboratory thermometer, measure the temperature of the test solution. At the Tripar rear panel, adjust the temperature "CAL" potentiometer until the Tripar display reads the value of the calibration solution.

Best results will be obtained if the temperature "ZERO" and "SPAN" calibration procedures are repeated.

Conductivity Calibration. From time to time, it will be required to calibrate the Tripar conductivity circuit. A simple two-point calibration procedure is utilized by first adjusting the conductivity zero and then the span.

Conductivity Zero Adjustment - With the conductivity sensor clean, dry, and in air, adjust the conductivity "zero" potentiometer for a reading of 0000 on the Tripar display.

Conductivity Span Adjustment - Totally immerse the Tripar conductivity sensor in calibration solution of known conductance. Note that the reading displayed on the Tripar is a temperature corrected value to 25°C. Therefore, the value of the standard solution must be calculated to 25°C. Also, the value of the calibration solution should fall in the upper 50 percent of the ranges to be calibrated; i.e., adjustment of the 1000 micromho/cm range should be accomplished with a 500 to 1000 micromho/cm standard. Once the sensor has stabilized in the solution for approximately one minute, adjust the conductivity "CAL" potentiometer at the Tripar rear panel for a reading on the display equal to the temperature corrected value of the standard solution.

Best results will be obtained if the conductivity zero and span procedures are repeated.

pH Calibration.

pH Standardization - The pH sensor should be standardized before each use after long storage. First, moisten the electrode body with tap water and carefully remove the plastic storage cap covering the tip of the electrode. Care should be taken not to bend the body of the electrode as this can result in damage to the internal element.

For first time use after long storage, immerse the lower end of the electrode in tap water for 30 minutes. This hydrates the pH bulb and prepares the ceramic wick for contact with test solutions. If air bubbles are present in the pH bulb, shake the electrode downward to fill the bulb with solution.

Prepare a small sample of pH 7.00 buffer solution and measure the temperature of the buffer. Rinse the pH electrode with distilled water and immerse the pH bulb in the reference buffer. Set the compensation dial in the Tripar front panel to the temperature of the buffer, allow several minutes for the sensor to reach equilibrium and stir the sensor slightly to dislodge any possible air bubbles from the electrode tip. Using the "Standardize" potentiometer, adjust for a reading of 7.00 on the Tripar display.

pH Slope Adjustment - Very infrequently, the pH slope adjustment may require re-calibration. This adjustment is available at the Tripar readout rear panel. To accomplish this adjustment, prepare a test solution of pH 4.00 or 10.00. Measure the temperature of the solution and make the appropriate setting at the pH "Compensation" dial. Rinse the pH electrode in distilled water and immerse in the buffer solution. Allow several minutes for the sensor to equilibrate and stir the electrode slightly. Using the pH "Slope" potentiometer available at the rear panel, adjust the Tripar readout module for a reading equal to the value of the buffer solution. For best results, the pH "Standardize" and "Slope" adjustments should be repeated at least once.

Note that some interference may be seen on the pH reading if the Tripar conductivity sensor is present in the same test solution as the pH sensor.

8.2.4 Photoionization Meters

HNU - With the probe attached to the instrument turn the function switch to the battery check position. The needle on the meter should read within or above the green battery area on the scale plate. If the needle is in the lower position of the battery arc, the instrument should be recharged prior to any calibration. If red LED comes "on", the battery should be recharged. Next, turn the function switch to the on position. In this position the UV light source should be on.

To zero the instrument, turn the function switch to the standby position and rotate the zero potentiometer until the meter reads zero. Clockwise rotation of the zero potentiometer produces an upscale deflection while counterclockwise rotation yields a downscale deflection. If the span adjustment setting is changed after zero is set, the zero should be rechecked and adjusted if necessary. Wait 15-20 seconds to ensure that the zero reading is stable. If necessary, readjust the zero.

The instrument is now ready for calibration by switching the function switch to the proper measurement range.

Using non-toxic analyzed gas mixtures available from the manufacturer in pressurized containers, connect the cylinder with the analyzed gas mixture to the end of the probe with a piece of tubing. Open the valve of the pressurized container until a slight flow is indicated and the instrument draws in the volume of sample required for detection. Now adjust the span potentiometer so that the instrument is reading the stated value of the calibration gas.

If the instrument span setting is changed, the instrument should be turned back to the standby position and the electronic zero should be readjusted if necessary. If the instrument does not calibrate, it may be necessary to clean the probe or the lamp connection.

Photovac T.I.P. - Turn power switch on by first pulling knob out and then up. Allow T.I.P. to warm up for 5 minutes prior to use. Turn span knob to max (9) and zero knob to zero. Attach "zero air" cylinder to T.I.P. inlet using PVC tubing. Zero instrument using zero knob only. (T.I.P. is very sensitive so stable reading of absolute zero is difficult and not necessary to achieve.) Next, attach isobutylene cylinder to T.I.P. inlet. Use the span knob to adjust T.I.P. reading to the concentration number on the isobutylene cylinder (usually 60 ppm). Remove cylinder. T.I.P. is now calibrated and ready for use. (Calibration should be checked often as T.I.P. has tendency to drift.) When finished, turn power off by pulling switch out and down. Recharge instrument overnight. (Battery charger must be pushed into place and then screwed into bottom of T.I.P.)

8.2.5 Organic Vapor Analyzer

The following information is presented as general guidelines. Specific OVA field protocols are generally site-specific and would be included with the site QAPP addendum.

Equipment Set-up:

Set up the Photovac 10A10 in a temperature-stable environment at least eight to ten hours before beginning analyses. Attach AC power cord to Photovac and plug into 110V power outlet. Attach recorder AC power cord to Linear recorder and plug into 110V power outlet. If fully charged, internal battery packs provide 6 to 8 hours operation as a portable instrument.

Connect coaxial cable to "output" jack on Photovac, and plug opposite end into +/- input jacks on records. If positive meter reading on the Photovac gives negative recorder response, reverse polarity of recorder by reversing plug in +/- jacks. Attach gas supply to either "carrier in" port and measure flow rate on "vent" and "out" ports with a bubble flow meter. Proper flow rate is 10-15 mℓ/min during analysis; ~5 mℓ/min on standby or overnight. Reduce flow rate for overnight flush by adjusting the air tank pressure regulator. Note: Use only "Zerograde" or better air as carrier. Plastic tubing is preferred for the connection.

Equipment Operation:

Use only air-tight syringes with sharp pointed needles to introduce samples into the Photovac. Any bend in the needle will damage the septum and analyzer will not be reliable. Pierce the septum of the sample container and rinse the syringe three or four times by working the plunger back and forth before filling with sample. Remove syringe and quickly adjust volume and make injection with no hesitation. Never remove or loosen caps or valves on sample containers. Once the septum on a sample container is pierced, complete all analyses on that sample as soon as possible, as some loss of contaminants may occur.

Never interrupt the carrier gas (air) supply without first turning the detector off! Change air tanks when pressure reaches ~300 psig, or at the end of the day if analyses are to be performed the following day (detector off while changing).

Set Photovac attenuation on 100 and range on x1. Start gas flow at 10 mℓ/min. Place "charge" switch in off position and turn detector switch on 30 minutes prior to beginning of analysis. Turn recorder chart drive off, and with the input voltage switch set at 100 mV, turn the recorder power on. Using the "zero" and "attenuation" knobs on the recorder, set so that a zero reading on the Photovac meter gives zero plot on the recorder, and so that 100 reading on Photovac gives full scale reading on recorder. (Turn the "offset" knob on the Photovac to make meter reading change.)

Turn the "offset" knob fully counterclockwise. Meter reading should be 20-50 percent of full scale. If higher, either the air supply is contaminated or the column needs to be flushed. The instrument can still be used in this condition, but the detector can easily be overloaded. Wait until reading is 20-50 percent if possible before analysis. Set the attenuation on the Photovac to the desired setting (e.g., 100 for "unknown" or dirty samples; 10 for low ppm standards or clean samples).

Rotate the offset knob clockwise until meter (and recorder) reads ~10 percent of full scale. Set the column selector switch to the desired column. Use column #1 (10 inches long) for screening unknown samples by injecting a small (~ five-$\mu\ell$) amount in port #1 to determine how much sample to inject in column #2 (four feet long) for analytical purposes. Use the results of this initial small injection on column #1 to avoid overloading column #2. If column #2 is overloaded, <u>it may take hours or even days before it is useful again</u>.

Reset the offset (if necessary) to give 10 percent full scale reading. Wait for meter to stabilize. Set recorder chart speed to 1 cm/min and turn chart drive on (flip switch up to cm/min setting). Inject sample or standard into proper port in a smooth motion and note on the recorder chart the moment of injection. Note on the chromatogram the sample or standard identification, volume injected, column #, range and attenuation (e.g., 100 x 1), chart speed and date.

Let chromatogram run until all compounds have eluted and the baseline has stabilized before making another injection (~15-20 minutes for column #1, ~30-60 minutes for column #2). Run standard mix every five or six samples to monitor changes in retention times or response. To interpret chromatograms, measure retention times from point of injection (1 cm = 1 min, or appropriate scale). Measure peak height from baseline to estimate quantity of a given compound, relating sample peak retention time and height to that of known standards. Peak height is directly proportional to concentration and to volume injected (e.g., if a 50 $\mu\ell$ injection of a 5 ppm standard gives a 5 cm peak with retention time of 114 seconds, a sample with a 3 cm peak at 112 seconds may contain 3 ppm of the same compounds if 50 $\mu\ell$ was injected).

<u>Typical Standards, Retention Times, Response Factors for the Photovac 10A10</u>. The retention times and response factors below are estimates based on laboratory work under controlled conditions (20°C and a carrier flow of 10-15 mℓ/min). Actual retention times and response factors must be acquired in the field under identical conditions to those under which samples will be run.

A table like that shown below must be generated prior to analysis of actual samples. Documentation must also include attenuation settings, column identification, head pressure and ambient conditions.

Compound	Mixed Standard Concentration (ppm)	Retention Time (seconds)	Response 50 μℓ Injection (cm)
methylene chloride	5.0	50	~10
1,1-dichloroethane	10.0	63	4.5
1,2-dichloroethane	20.0	100	4.5
benzene	1.0	110	6.5
toluene	2.0	285	5.8
1,1,2,2-tetrachloroethylene	2.0	340	7.1
chlorobenzene	2.0	435	7.3
xylenes	10.0	615,665,800	1.0,4.3,1.3

9.0 ANALYTICAL PROCEDURES

9.1 SELECTION OF PARAMETERS

Laboratory analyses may be scheduled for air, water, sediment, soil or waste samples. Based on historical information regarding potentially hazardous material use and disposal, previous site assessments and legislative mandates, Jordan may select some or all of the following parameter groups for analysis at a particular site:

- volatile organics;
- extractable organics;
- pesticides/PCBs;
- elements/inorganics; and
- extraction procedure toxicity (EPTox).

Any additional laboratory analyses will be presented and their selection justified in the site-specific QAPP addendum. Individual contaminants comprising the analytical fractions noted above are contained in USEPA's Hazardous Substance List and/or the analytical methods selected.

9.2 SELECTION OF PROCEDURES

The analytical procedures appropriate for the majority of this program were selected based upon the IRP's legislative mandate - CERCLA. The level of analytical quality and forensic documentation indicated by this mandate normally leads to a selection of the USEPA CLP Caucus Organics Protocol (COP) and Caucus Inorganics Protocol (CIP). These state-of-the-art analytical protocols were developed with the basic requirement of legally defensible data outputs as a central criterion. Analytical protocols and data deliverables are specified in USEPA's solicitation Statement of Work for the CLP.

In some instances, however, the above protocols are not appropriate. For example, the implementation of a water supply study would require the analytical procedures to be selected based upon the requirements of the Safe Drinking Water Act.

Each site-specific QAP addendum will list the methods selected for that task. A typical summary appears as Table 9-1. Note that the selection of CLP methods requires that the laboratory analyze matrix spike and matrix spike duplicate (MS/MSD) samples as part of laboratory QC. The sampling program must provide sufficient sample to accomplish this. For every 20 sample batches or for a group of samples less than 20 collected within a 30 day period, one sample set must be collected in triplicate. The location of triplicate sampling should be selected to best enhance the achievement of project objectives.

TABLE 9-1
EXAMPLE SUMMARY OF ANALYTICAL METHODS
FOR SITE-SPECIFIC QAP ADDENDUM

ANALYTICAL DATA

MATRIX/PARAMETER		ANALYTICAL METHOD
Site 19B. Maintenance Area Around Hangers		
Water:	Purgeable Organics	EPA Method 624
	Semivolatile Organics	EPA Method 625
	Pesticides/PCBs	EPA Method 608
	PP Metals	EPA Method 200.7
Site 20B. Abandoned Underground Storage Tanks and Fuel Pits		
Water:	Purgeable Organics	EPA Method 624
	Semivolatile Organics	EPA Method 625
	Pesticides/PCBs	EPA Method 608
	PP Metals	EPA Method 200.7
Site 21B. Rubble Landfill		
Soil:	Purgeable Organics	EPA Method 8240
	Semivolatile Organics	EPA Method 8250
	Pesticides/PCBs	EPA Method 8080
	PP Metals	EPA Method 6010
Site 22B. Old Fire Demonstration Area		
Soil:	Lead	EPA Method 6010
Site 23B. Drainage Ditch Leading to Sandy Creek		
Sediment:	Purgeable Organics	EPA Method 8240
	Semivolatile Organics	EPA Method 8250
	Pesticides/PCBs	EPA Method 8080
	PP Metals	EPA Method 6010
Soil:	Lead	EPA Method 6010
	Polynuclear Aromatic Hydrocarbons	EPA Method 8100
Water:	Purgeable Organics	EPA Method 624
	Semivolatile Organics	EPA Method 625
	Pesticides/PCBs	EPA Method 608
	PP Metals	EPA Method 200.7

10.0 DATA REDUCTION, INTERPRETATION, VALIDATION AND REPORTING

Data reduction is the process of converting measurement system outputs to an expression of the parameter which is consistent with the comparability objective. Calculations made during data reduction are described in the referenced analytical methods.

Interpretation of measurements by Jordan is a systematic process of reviewing a body of data to provide assurance that the data are adequate for their intended use. The process includes the following activities:

- auditing measurement system calibration and calibration verification;
- auditing QC activities;
- screening data sets for outliers;
- reviewing data for technical credibility vs. the sample site setting;
- auditing field sample data records and COC;
- checking intermediate calculations; and
- certifying the process above.

Field data collection and interpretation will follow the process illustrated as Figure 10-1. Prior to data collection, determinations are made regarding the data to be gathered in the field and the methodology to be used. Once the data are obtained, they will be reviewed and assessed as to their adequacy. If it is determined that the initial data collection concept did not provide adequate data, the entire process may need to be repeated to identify and correct data inadequacies.

For most IRP projects, formal data validation in accordance with USEPA's functional guidelines will not be performed by Jordan with the exception of interpretation to account for laboratory method blank contamination. However, the analytical events will be documented and forensic records kept to allow validation to occur at a later date, if required. For those projects requiring data validation, Jordan will perform data validation on those measurements requiring it.

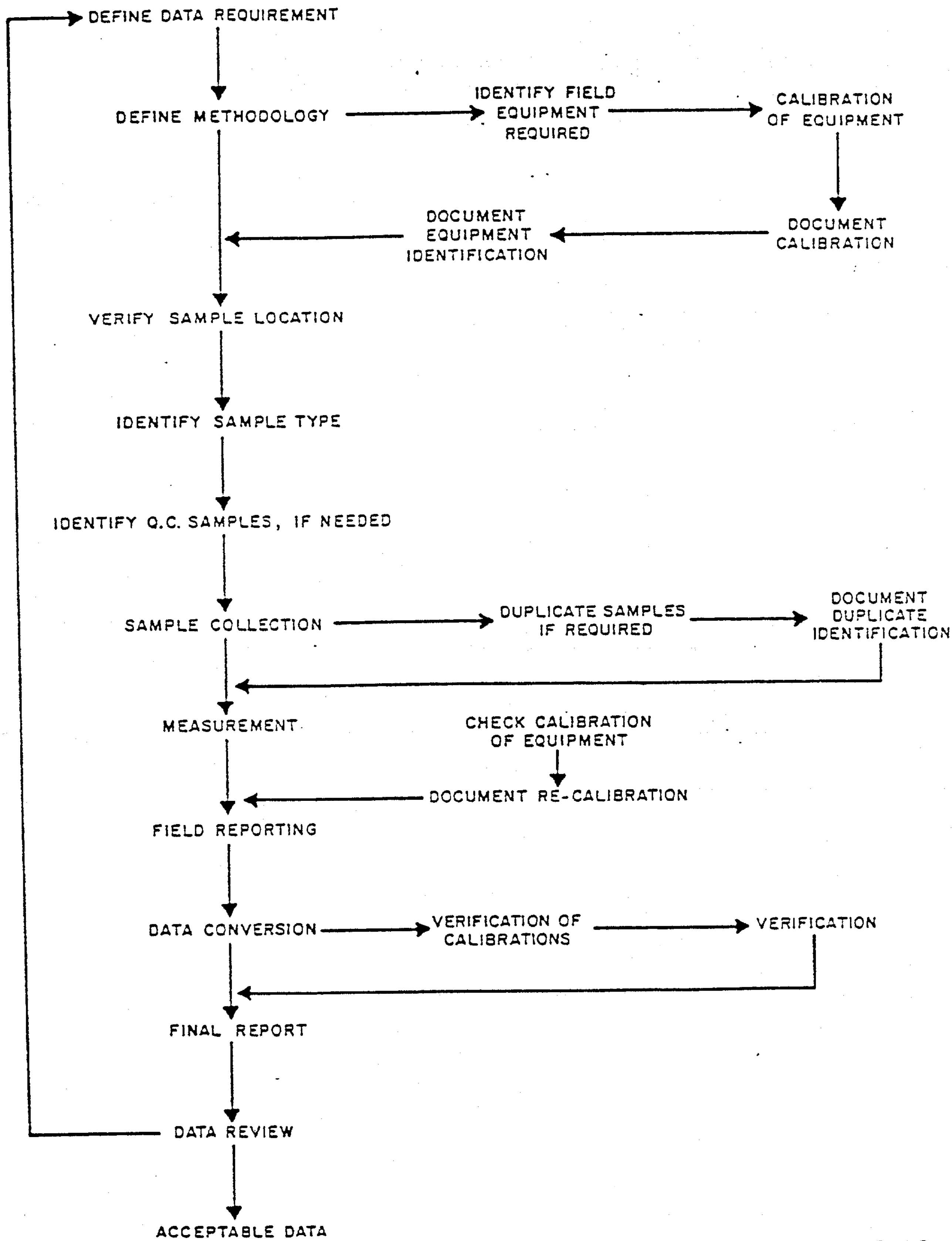

FIGURE 10-1
FIELD DATA COLLECTION AND VALIDATION

E.C.JORDAN CO.

11.0 INTERNAL QUALITY CONTROL

11.1 MEASUREMENT SYSTEMS

Quality control procedures have been established for Jordan's field activities. Field QC activities include the use of calibration standards and blanks for pH, specific conductance, temperature and photoionization measurements. Special samples to be submitted to the laboratory include:

- trip blanks;
- duplicates;
- sampler blanks; and
- filtration blanks.

These samples provide a quantitative basis for evaluating the data reported.

Although the number of QC samples changes, the types of field QC samples remain the same, regardless of the level of QC implemented. Table 11.1 lists the percentage of field QC samples by level for each sample matrix per event. A sampling event is considered to be from time for sampling personnel arrive at the site until these be from the time the sampling personnel arrive at the site until these personnel leave for more than 24 hours. An event may span more than one day.

Table 11.1
Field Quality Control Samples Per Sampling Event

Type of sample	Level D		Level C		Level E	
	Metal	Organic	Metal	Organic	Metal	Organic
Trip blank (for volatiles only)	NA[1]	1/cooler	NA[1]	1/cooler	NA[1]	1/cooler
Equipment rinsate[2]	1/source/event for all levels and all analytes					
Field duplicates[3]	10%	10%	10%	10%	5%	5%
Referee duplicates[3]	collect at direction of IRP Engineer in Charge					

NOTE:

[1] NA - Not applicable

[2] Samples are collected daily; however, only samples from every other day are analyzed. Other samples are held and analyzed only if evidence of contamination exists.

[3] The duplicate must be taken from the same sample which will become the laboratory matrix/spike duplicate for organics or for the sample used as a duplicate in inorganic analysis.

Trip Blanks

Trip Blanks are defined as samples that originate from analyte-free water taken from the laboratory to the sampling site, placed in sample vials in the field, and returned to the laboratory with the volatile organic samples. One trip blank should be prepared in the file and accompany each cooler containing volatile organic aromatics (VOAs), should be stored at the laboratory with the samples, and analyzed with the sample set. Trip blanks are only analyzed for VOAs.

Equipment Sampler Rinsates

Equipment rinsates are the final analyte-free water rinse from equipment cleaning and are collected daily during a sampling event. Initially, samples from every other day should be analyzed. If analytes pertinent to the project are found in the rinsate, the remaining samples must be analyzed. The results from the blanks will be used to qualify the levels of analytes in the samples. This qualification is made during data validation. The rinsates are analyzed for the sample analytes as the samples which are collected that day.

Field Blanks

Field blanks, also known as source water samples, are the water used in decontamination and steam cleaning. At a minimum, one sample from each event and each source of water will be collected and analyzed. These should be collected in the appropriate container for the desired water analysis.

Field Duplicates/Splits

Duplicates or splits for soil or sediment samples, except VOA samples are collected, composited and then split. If the samples are collected from a split spoon, the contents of the spoon should be quartered, each quarter mixed separately and then a sample jar filled with equal portions from each quarter. VOA samples are not mixed, but taken as grab samples. If the samples are collected using "California Tubes", the laboratory should be instructed to analyze both an original and a duplicate sample from each tube.

Duplicates for water samples are collected as follows: All VOA vials (for the sample and duplicate) are filled first. The samples and duplicates for the remaining parameters are composited as follows: The bottles for a parameter (ex: semi) including those for the duplicates are filled by dividing the contents of each bailer or sampling device between all the bottles for that particular parameter until they are filled.

The matrix constitutes soil, water, or waste, from a given site. All the duplicates will be sent to the primary laboratory responsible for analysis. The same samples used for field duplicates will be taken in sufficient volume to be split by the laboratory and be used as the laboratory duplicate or matrix spike. This means that for the duplicate sample, there will be the normal sample analysis, and the laboratory matrix split/matrix spike duplicate analysis.

Referee Laboratory Duplicates

Duplicates/splits will be sent to the referee QA laboratory if regulators (state of region) collect split samples or if a special problem occurs in sample analysis or collection. These duplicates/split are collected and analyzed in addition to the field duplicates mentioned in the previous paragraph. These are collected only at the direction of the IRP Engineer in Charge. To differentiate these samples from field duplicates, they will be identified as Replicates.

Completeness

Completeness of scheduled sample collection will be controlled in the field by comparing a computer generated label inventory with samples actually collected each day. Daily checking of field data sheets and comparison of transport and chain-of-custody logs will provide further control of documentation and completeness.

Evaluating Laboratory Assays of QC Control Samples and Field Replicates

Establishment of specific criteria for evaluation depends to a great extent on the number of field and quality control samples for each media sampled, the quality of chemical data generated and how the data will be used in interpreting, evaluating and assessing the site. Chemical assay results of a particular sample may be used for more than one purpose. Chemical assay results of quality control samples may be considered differently depending on how the data will be used.

At least the following items are evaluated by the professional responsible for assessing site conditions:

- Quality of Laboratory Data:
  - acceptable
  - provisional
  - unacceptable

- Method Limitations:
  - dynamic range
  - accuracy
  - method detection limits (MDL)
  - practical quantitation level (PQL)
  - precision

- Sampling/Analysis Scope and Results:
  - number of replicates at one location
  - number of samples on site/media
  - background/downgradient distribution
  - consistency/trends of chemical assay data collected at site
  - agreement with existing site information

- Use of Data:
  - chemical distribution and transport at the site (generally order of magnitude comparisons)
  - compliance with standards, regulations, response objectives
  - presence or absence of chemical
  - treatability
  - disposal method for media containing chemicals
  - risk assessment
  - litigation

11.2 QUALITY REVIEW OF STUDIES AND REPORT PREPARATION

The purpose of quality reviews through the course of studies, designs and reports is to ensure that the service, designs and documents produced by each department meet currently accepted professional standards. The level of effort for each assignment will vary depending on type of assignment, duration and size. Review of small projects may entail periodic discussions between Technical Staff, the TD and PM. Quality control on larger assignments may require that the review personnel be involved. Quality control reviews should be scheduled on a routine basis, but the option of holding a QC review at any time is always open. The time required to plan, schedule, and conduct QC reviews should be considered part of all other design, writing and checking phases of a project.

Each assignment is normally divided into phases for internal QC reviews. At each phase, the review should include client goals, contractual commitments, technical merit, timing, budget, assignment of appropriate personnel, department coordination, project problem resolution, documentation, and consistency with company policy. Key elements to the success of any QC review are identification of problem areas, communication to implement solutions, and follow-up. Due to the complexity and interlocking nature of the IRP tasks, reviews have been scheduled weekly to ensure rapid communication.

Quality control during the preparation of studies and reports relies on documentation of data utilized and peer review of conclusions drawn from the assembled data base. The comparability objective established for the project is of particular importance when data are derived from many sources (i.e., the data base is comprised of secondary measurements). Documentation of secondary data typically is accomplished via data verification/tracking checklists with accompanying written criteria describing "acceptable" data to insure consistency in data selection. This allows all data base components to be traced to the primary generator and forces a review of data quality as the data base is developed. All project personnel are responsible for utilization and monitoring of this process; compliance is audited by the QAO. Upon completion of the data base, data interpretation, evaluation, and report preparation commence. Interpretation may require consultation with Jordan's statistician and/or use of computerized statistical routines. Documentation is also prepared for statistical manipulation methodologies. Data evaluation incorporates peer review to provide broad-based insight to data correlations and interactions.

To enhance the professional quality of the company's studies and reports, discipline managers will also:

- require that reports refer to and are consistent in scope with the project proposal and contract; and

- require that report language and contents be chosen to foster client's understanding of risks and uncertainties by distinguishing fact from opinion and identifying risks and limitations in a clear and informative manner.

Implementation of QC for reports involves the use of a review routing and sign-off forms. The Technical Director provides final review and release for all deliverables.

12.0 AUDITS

Quality assurance audits are performed to assure and document that QC measures are being utilized to provide data of acceptable quality and that subsequent calculations, interpretation and other project outputs are checked and validated. Both scheduled and unscheduled audits are provided for in the QA program.

System and performance audits may be conducted by the QAO. The TRB may conduct project audits of calculations, interpretations and reports which are based on the measurement system outputs.

12.1 SYSTEMS AUDIT

A system audit may be conducted on all components of measurement systems to determine proper selection and utilization. The systems audit includes evaluation of both field and laboratory procedures.

Organization and Personnel. The project organization is reviewed for compliance with the proposed organization and for clarity of assigned responsibility. Personnel assigned to the project will be reviewed to determine that assigned responsibility, skill and training of the personnel are properly matched. The Task Manager maintains firsthand knowledge of his team's capabilities and will discuss the organization's efficacy with the QAO. Assigned personnel may be interviewed by the QAO during an audit.

Facilities and Equipment. The audit will address whether field equipment and analytical instruments are selected and used to meet requirements specified by the project objectives stated in the QAPP. Equipment and facilities provided for personnel health and safety may also be evaluated. Calibration and documentation procedures for instruments used in the field also receives attention.

Analytical Methodology. A review of analytical methodology in regard to the data requirements for the project will be performed. An on-site observation of analyst technique, data reduction and record keeping may be performed if determined necessary. Periodic review of precision and accuracy data is essential.

Sampling and Sample Handling Procedure. An audit of scheduled samples vs samples collected vs samples received for analysis may be performed. Field documentation may be reviewed. If deemed necessary, a site visit will be made to assure that designated control procedures are practiced during sampling activities.

Data Handling. During a system audit, the QAO will review data handling procedures with the TD. Accuracy, consistency, documentation, and appropriate selection of methodologies will be discussed.

12.2 PERFORMANCE AUDIT

These audits are intended primarily for analytical data generation system and are provided in the laboratory's QAP.

12.3 PROJECT REVIEW

Project reviews are scheduled and conducted by the department responsible for the project. The intent of project reviews is to assess scope compliance and overall technical quality of the contracted services. Senior technical staff, selected by the Department Manager, apply the accumulated experience of the company to a service during the conduct of the work. A project review is appropriate at, for instance, work plan finalization, selection of design criteria, end of field program, determination of conclusion and recom-mendations, or the traditional stages of design completion. Documentation of the project review, especially identified action items and their follow-up, is essential to maximizing the utility of these reviews. Figure 12-1 provides an example project review record.

12.4 QA AUDIT REPORT

A written report of the QA project audit is prepared to include:

- an assessment of project team status in each of the major project areas;
- clear statements of areas requiring improvement or problems to be corrected. Recommendation and assistance will be provided regarding proposed corrective actions or system improvements. If no action is required, the report will state that the QA audit was satisfactorily completed; and
- a timetable for any corrective action required.

Figure 12-2 provides an example QA Audit Report. Distribution of the report will include the TRB, CO, TD, and PM.

FIGURE 12-1
PROJECT REVIEW RECORD

Project Name:
Project No.:
Site/Location:
Client:
Project Type:

Date:
Project Professional:

Department:

Objective of the Review:

Reviewers: 1.
2.
3.

Consensus Review Comments:

1.

2.

3.

4.

5.

Follow-up Actions:

1.

2.

3.

4.

5.

Date Follow-up Completed:

Project Professional:________________

Department Manager:________________

Distribute when completed to: VP-QA, Dept. Mgr., Project File, Reviewers

FIGURE 12-2

QUALITY ASSURANCE AUDIT REPORT

Project: ______________________________

Project No.: ____________ Quality Assurance Coordinator: ________________

Project Aspects Audited: ______________________________

Laboratory/Technical Director: ______________________________

Audit Conducted By: ________________ for the period __________ to __________

Date of Audit: ______________________________

Personnel Interviewed: ______________________________

Purpose and Objectives of the Project Aspects Audited

Brief Description of the Sampling and Analytical Requirements

FIGURE 12-2 (Continued)
RESULTS OF THE QUALITY ASSURANCE AUDIT

Organization and Personnel

Facilities Utilized

Analytical Methodologies

DOC
5

FIGURE 12-2 (Continued)
RESULTS OF THE QUALITY ASSURANCE AUDIT

Sampling and Sample Handling

Quality Control Measures Utilized

Data Handling

FIGURE 12-2 (Continued)
RESULTS OF THE QUALITY ASSURANCE AUDIT

Quality Assurance Deficiencies

Recommended Corrective Actions and Schedule

Signed Date

Title

Distribution:

Reviewed by Date

Title

13.0 PREVENTIVE MAINTENANCE

13.1 ANALYTICAL INSTRUMENTATION

Preventive maintenance of analytical instrumentation is addressed by the selected laboratories' standard operating procedures.

13.2 FIELD INSTRUMENTS

Preventive maintenance of field equipment is performed by analysts and staging area staff and routinely precedes each sampling event; more extensive maintenance is performed on the basis of hours in use. Sampling crews report on the performance of the equipment after each sampling event. Critical spare parts are kept in stock.

14.0 DATA ASSESSMENT

14.1 GENERAL

The purpose of data quality assessment is to assure that data generated under the program are accurate and consistent with project objectives. The quality of data will be assessed based on the precision, accuracy, consistency and completeness of the data that are generated.

Data quality assessment will be conducted in three phases:

Phase 1

Prior to data collection, sampling and analysis procedures are evaluated in regard to their ability to generate the appropriate, technically acceptable information required to achieve project objectives. This QAPP meets this requirement by establishing project objectives defined in terms of parameters, analytical methods, and required sampling protocols.

Phase 2

During data collection, results will be assessed to assure that the selected procedures are efficient and effective and that the data generated provides sufficient information to achieve project objectives. The appropriateness of the precision and accuracy of selected measurement systems will also be evaluated. In general, evaluation of data will be based on performance audits, results of duplicate and spiked sample analyses, and review of completeness objectives.

Documentation may include:

- number of replicate samples collected;
- number of replicate, spike and field blank samples analyzed;
- identification of statistical techniques, if used, to measure central tendency, dispersion, or testing for outliers;
- use of historical data and its reference; and
- identification of analytical method.

Phase 3

Following completion of data collection activities, an assessment of the adequacy of the data base generated in regard to completing project objectives will be undertaken by the QAO and Task Manager. Recommendations for improved quality control will be developed, if appropriate. In the event that data gaps are identified, the auditor may recommend the collection of additional raw data to fully support the project's findings and recommendations.

Each phase of the assessment will be conducted in conjunction with appropriate project staff.

14.2 PROCEDURES TO ASSESS PRECISION AND ACCURACY

Assessment of precision and accuracy of analytical data is accomplished via review of duplicate analyses (precision) and surrogate spike recovery (accuracy) both in reagent water and sample matrices. Precision is generally expressed as the coefficient of variation (CV). Accuracy is expressed as percent recovery. Precision must be assessed for each matrix since distribution of contaminants may be non-homogeneous, especially in non-water matrices. Precision in samples must be reviewed with knowledge of the matrix and level of analyte present. Corrective action or documentation of substandard precision is a laboratory responsibility. Accuracy, too, must recognize the impact of matrix interferences. Optional surrogate/spike recoveries are generally specified by the analytical method for reagent water under defined conditions. Each method which provides quality control requirements and acceptance criteria also specifies the method of generating the data to be reviewed. It is the laboratory's responsibility to attempt to identify the source of substandard recoveries and either take corrective action or document the cause.

Calculations are presented below:

$$\%R = \frac{\text{observed value}}{\text{theoretical value}} \times 100$$

$$CV = (S/X) \times 100$$

where %R = percent recovery

CV = coefficient of variation

S = sample standard deviation

X = mean value of data set

Completeness is generally assessed as a percentage of data intended to be generated, and is most often utilized in Phase 3 of the data assessment process.

DOC
2

15.0 CORRECTIVE ACTION

Corrective or preventive action is required when potential or existing conditions are identified that may have an adverse impact on data quantity or quality. Corrective action could be immediate or long-term. In general any member of the program staff who identifies a condition adversely affecting quality can initiate corrective action by notifying in writing his or her supervisor and the QAO. The written communication will identify the condition and explain how it may affect data quality or quantity.

15.1 IMMEDIATE CORRECTIVE ACTION

Immediate corrective action is usually applied to spontaneous, non-recurring problems, such as an instrument malfunction. The individual who detects or suspects nonconformance to previously established criteria or protocol in equipment, instruments, data, methods, etc., will immediately notify his/her supervisor. The supervisor and the appropriate task leader will then investigate the extent of the problem and take the necessary corrective steps. If a large quantity of data is affected, the task leader must prepare a memorandum to the Project Manager and the QAO. These individuals will collectively decide how to proceed. If the problem is limited in scope, the task leader will decide on the corrective action measure, document the solution and notify the Technical Director and the QAO in memorandum form.

15.2 LONG-TERM CORRECTIVE ACTION

Long-term corrective action procedures are devised and implemented to prevent the recurrence of a potentially serious problem. The QAO will be notified of the problem and will conduct an investigation to determine the severity and extent of the problem. He will then file a corrective action request with the Technical Director and Technical Review Board (TRB). In case of dispute between the TRB and the PM, the Corporate Officer (CO) will make a final determination for the company.

Corrective actions may also be initiated as a result of other activities, including:

- Performance Audits;
- System Audits;
- Laboratory/field comparison studies; and
- QA project audits conducted by the TRB or QAO.

The QAO will be responsible for documenting all notifications, recommendations, and final decisions. The PM and the QAO will be jointly responsible for notifying program staff and implementing the agreed upon course of action. The QAO will be responsible for verifying the efficacy of the implemented actions. The development and implementation of preventive and corrective actions will be timed, to the extent possible, so as to not adversely impact either project schedules or subsequent data generation/processing activities. The QAO will also be responsible for developing and implementing routine program controls to minimize the need for corrective action.

16.0 REPORTS TO MANAGEMENT

Summary audit reports may be prepared coincident to the completion of each Task to inform task staff and management of QA status. A final audit report for each project will also be prepared. The reports would include:

- periodic assessment of measurement data accuracy, precision and completeness;
- results of performance audits and/or systems audits;
- significant QA problems and recommended solutions for future projects; and
- status of solutions to any problems previously identified.

Additionally, any incidents requiring corrective action will be fully documented. Procedurally, the QAO will prepare the reports to management. These reports will be addressed to the Technical Director and the Technical Review Board. The summary of findings shall be factual, concise and complete. Any required supporting information will be appended to the report.

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN ADDENDUM FORMAT

Task Quality Assurance Plan Addendum

IRP - SITE NAME

Task: (Number & Title)

Task Objective:

Subtasks	Standard Protocol Selected
Sample Wells	reference section # of QAPP or explain protocol to be used

Task Organization

Name	Function

Subcontractors	Function

Local Contacts	Function

Insert Sampling Data

Sample Identification/Cross Reference

ECJ ID No.	Sample Locations

APPENDIX C

SITE-SPECIFIC QUALITY ASSURANCE PLAN
ADDENDUM

SITE-SPECIFIC QUALITY ASSURANCE PLAN ADDENDUM

Task: NAS Whiting Field Remedial Investigation

Task Objectives:

- locate contaminant source areas;
- assess the nature and distribution of contaminants found in the soil, sediment, groundwater, and surface water;
- characterize regional and local hydrogeology;
- provide the necessary data base for the Risk Assessment; and
- obtain data for evaluating remedial alternatives.

Subtasks:	Standard Protocol Selected
Soil Sampling	QAPP, Section 6.6.2
Surface Soil Sampling	QAPP, Section 6.6.4
Drilling and Monitoring Well Installation	See Standard Specifications for Subsurface Boring and Sampling
Groundwater Sampling	QAPP, Section 6.7.2
Surface Water Sampling	QAPP, Section 6.7.3
Piezocone Penetration Tests	ASTM D3441-86
Laboratory Analysis	Laboratory NEESA Approved QAPP
Pumping Test	SOP Attached
Slug Test	SOP Attached
Gamma Log	SOP Attached

TASK ORGANIZATION

NAME	FUNCTION
T. Allen	Program Manager/Project Manager
J. Davis	H&S Officer
M. Nugent	Technical Director/QA Officer
E. Blomberg	RI Task Leader/FOL
J. Burris	HSO Designee-Field

Subcontractors (Competitive Bid)

To Be Determined	Chemical Analysis
To Be Determined	Boring and Well Installation
Williams & Associates	PCPT Explorations and In-situ Groundwater Sampling
To Be Determined	Survey

Local Contacts

C. Black	NAS Whiting Field Point of Contact

ANALYTICAL DATA

MATRIX	PARAMETER	ANALYTICAL METHOD	NEESA QC LEVEL
Site 1. Northwest Disposal Area			
Groundwater:	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C
Site 3. Underground Waste Solvent Storage Area			
Groundwater:	TCL Volatile Organic	CLP-COP	C
	TAL Metals	CLP-CIP	C
Site 6. South Transformer Oil Disposal Area			
Soil:	PCBs	CLP-COP	C/D
Site 9. Waste Oil Disposal Pit			
Groundwater:	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C
Site 10. Southeast Open Disposal Area (A)			
Groundwater:	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C
Site 11. Southeast Open Disposal Area (B)			
Groundwater:	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C
Site 12. Tetraethyl Lead Disposal Area			
Groundwater:	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C
Sediment:	TCL Volatiles	CLP-COP	C/D
	TCL Semivolatiles	CLP-COP	C/D
	TCL Pesticides/PCBs	CLP-COP	C/D
	TAL Inorganics	CLP-CIP	C/D
Soil:	Total lead	EPA Method 3050/7420	E
	TCLP		E
	Reactivity	SW-846	E
	Corrosivity	SW-846	E
	Ignitability	SW-846	E

ANALYTICAL DATA (cont.)

MATRIX	PARAMETER	ANALYTICAL METHOD	NEESA QC LEVEL
Site 13. Sanitary Landfill			
Groundwater	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C
Site 14. Short-Term Sanitary Landfill			
Groundwater:	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C
Site 15. Southwest Landfill			
Groundwater:	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C
Sediment:	TCL Volatiles	CLP-COP	C/D
	TCL Semivolatiles	CLP-COP	C/D
	TCL Pesticides/PCBs	CLP-COP	C/D
	TAL Inorganics	CLP-CIP	C/D
Soils:	TCL Volatiles	CLP-COP	C/D
	TCL Semivolatiles	CLP-COP	C/D
	TCL Pesticides/PCBs	CLP-COP	C/D
	TAL Inorganics	CLP-CIP	C/D
Site 16. Open Disposal and Burn Area			
Groundwater	TCL Volatile	CLP-COP	C
	TAL Metals	CLP-CIP	C
Soils:	TCL Volatiles	CLP-COP	D
	TCL Semivolatiles	CLP-COP	D
	TCL Pesticides/PCBs	CLP-COP	D
	TAL Inorganics	CLP-CIP	D
Site 17, 18. Crash Crew Training Area			
Groundwater:	TCL Volatile Organics	CLP-COP	C
	TAL Metals	CLP-CIP	C

ANALYTICAL DATA (cont.)

MATRIX	PARAMETER	ANALYTICAL METHOD	NEESA QC LEVEL
Clear Creek/Big Coldwater Creek			
Surface Water	TCL Volatiles	CLP-COP	C/D
	TCL Semivolatiles	CLP-COP	C/D
	TCL Pesticides/PCBs	CLP-COP	C/D
	TAL Inorganics	CLP-CIP	C/D
Sediment:	TCL Volatiles	CLP-COP	C/D
	TCL Semivolatiles	CLP-COP	C/D
	TCL Pesticides/PCBs	CLP-COP	C/D
	TAL Inorganics	CLP-CIP	C/D

SAMPLE IDENTIFICATION/CROSS REFERENCE

IN-SITU GROUNDWATER SAMPLE IDENTIFICATIONS

SITE NUMBER	SAMPLE NUMBER	APPROXIMATE DEPTH (FEET BLS)
1	WHF-1-WP-01-01	85
	WHF-1-WP-01-02	170
3	WHF-3-WP-01-01	110
	WHF-3-WP-01-01A	110
	WHF-3-WP-01-02	200
	WHF-3-WP-01-02A	200
	WHF-3-WP-02-01	110
	WHF-3-WP-02-02	200
9	WHF-9-WP-01-01	75
10	WHF-10-WP-01-01	75
	WHF-10-WP-02-01	75
	WHF-10-WP-02-02	150
11	WHF-11-WP-01-01	50
12	WHF-12-WP-01-01	90
	WHF-12-WP-01-01A	90
	WHF-12-WP-01-02	160
13	WHF-13-WP-01-01	80
	WHF-13-WP-02-01	80
	WHF-13-WP-02-02	130
14	WHF-14-WP-01-01	90
	WHF-14-WP-01-02	160
15	WHF-15-WP-01-01	?
	WHF-15-WP-01-01A	
	WHF-15-WP-01-02	100
	WHF-15-WP-02-01	?
	WHF-15-WP-02-02	100
16	WHF-16-WP-01-01	?
	WHF-16-WP-01-02	80
	WHF-16-WP-02-01	?
	WHF-16-WP-02-02	80
17	WHF-17-WP-01-01	?
18	WHF-18-WP-01-01	100
	WHF-18-WP-01-01A	100
	WHF-18-WP-01-02	200
	WHF-18-WP-01-02A	200

IN-SITU GROUNDWATER SAMPLES

SITE NUMBER	SAMPLE NUMBER	APPROXIMATE DEPTH (FEET BLS)
W-W3	WHF-W3-WP-01-01	100
	WHF-W3-WP-01-02	200
	WHF-W3-WP-02-01	100
	WHF-W3-WP-02-02	200
	WHF-W3-WP-03-01	100
	WHF-W3-WP-03-02	200
	WHF-W3-WP-04-01	100
	WHF-W3-WP-04-02	200
	WHF-W3-WP-05-01	100
	WHF-W3-WP-05-02	200
	WHF-W3-WP-06-01	100
	WHF-W3-WP-06-02	200
	WHF-W3-WP-07-01	100
	WHF-W3-WP-07-02	200
	WHF-W3-WP-08-01	100
	WHF-W3-WP-08-02	200
	WHF-W3-WP-09-01	100
	WHF-W3-WP-09-02	200
W-S2	WHF-S2-WP-01-01	100
	WHF-S2-WP-02-01	100
	WHF-S2-WP-03-01	100
	WHF-S2-WP-04-01	100
	WHF-S2-WP-05-01	100
	WHF-S2-WP-06-01	100
	WHF-S2-WP-07-01	100
	WHF-S2-WP-08-01	100

SOILS SAMPLES

SITE NUMBER	SAMPLE NUMBER	LOCATION
6	WHF-6-SL-01(0-0.5)-01	See Figure 3-13, SAP
	WHF-6-SL-01(0-0.5)-01A	
	WHF-6-SL-02(0-0.5)-01	
	WHF-6-SL-04(0-0.5)-01	
	WHF-6-SL-05(0-0.5)-01	
	WHF-6-SL-06(0-0.5)-01	
	WHF-6-SL-07(0-0.5)-01	
	WHF-6-SL-08(0-0.5)-01	
	WHF-6-SL-09(0-0.5)-01	
	WHF-6-SL-10(0-0.5)-01	
	WHF-6-SL-11(0-0.5)-01	
	WHF-6-SL-12(0-0.5)-01	
	WHF-6-SL-12(0-0.5)-01A	
	WHF-6-SL-12(0-0.5)MS	
	WHF-6-SL-12(0-0.5)MSD	
12	WHF-12-SL-01(1-2)-01	See Figure 3-12, SAP
	WHF-12-SL-02(1-2)-01	
	WHF-12-SL-03(1-2)-01	
	WHF-12-SL-04(1-2)-01	
	WHF-12-SL-05(1-2)-01	
	WHF-12-SL-06(1-2)-01	
15	WHF-15-SL-01(0-0.5)-01	See Figure 3-16, SAP
	WHF-15-SL-02(0-0.5)-01	
	WHF-15-SL-03(0-0.5)-01	
	WHF-15-SL-03(0-0.5)-01A	
	WHF-15-SL-03(0-0.5)-01MS	
	WHF-15-SL-03(0-0.5)-01MSD	
16	WHF-16-SL-01(0-0.5)-01	See Figure 3-16, SAP
	WHF-16-SL-02(0-0.5)-01	
	WHF-16-SL-03(0-0.5)-01	

SEDIMENT SAMPLES

SITE NUMBER	SAMPLE NUMBER	LOCATION
12	WHF-12-SD-01(1-2)-01	See Figure 3-16, SAP
	WHF-12-SD-02(1-2)-01	
	WHF-12-SD-03(1-2)-01	
15	WHF-15-SD-01(0-1)-01	See Figure 3-17, SAP
	WHF-15-SD-02(0-1)-01	
	WHF-15-SD-03(0-1)-01	
STA1	WHF-STA1-SD-01(0-1)-01	See Figure 3-5, SAP
STA2	WHF-STA2-SD-01(0-1)-01	
STA3	WHF-STA3-SD-01(0-1)-01	
STA4	WHF-STA4-SD-01(0-1)-01	
STA5	WHF-STA5-SD-01(0-1)-01	
STA6	WHF-STA6-SD-01(0-1)-01	
STA7	WHF-STA7-SD-01(0-1)-01	
STA8	WHF-STA8-SD-01(0-1)-01	
STA9	WHF-STA9-SD-01(0-1)-01A	
	WHF-STA9-SD-01(0-1)-01MS	
	WHF-STA9-SD-01(0-1)-01MSD	
STA10	WHF-STA10-SD-01(0-1)-01	
STA11	WHF-STA11-SD-01(0-1)-01	
STA12	WHF-STA12-SD-01(0-1)-01A	

SURFACE WATER SAMPLES

SITE NUMBER	SAMPLE NUMBER	LOCATION
STA1	WHF-STA1-SW-01-01	See Figure 3-5, SAP
STA2	WHF-STA2-SW-01-01	
STA3	WHF-STA3-SW-01-01	
STA4	WHF-STA4-SW-01-01	
STA5	WHF-STA5-SW-01-01	
STA6	WHF-STA6-SW-01-01	
STA7	WHF-STA7-SW-01-01	
STA8	WHF-STA8-SW-01-01	
STA9	WHF-STA9-SW-01-01	
	WHF-STA9-SW-01-01A	
	WHF-STA9-SW-01-01MS	
	WHF-STA9-SW-01-01MSD	
STA10	WHF-STA10-SW-01-01	
STA11	WHF-STA11-SW-01-01	
STA12	WHF-STA12-SW-01-01	
STA12	WHF-STA12-SW-01-01A	

TECHNICAL MEMORANDUM

PREPARED BY: L.L. Dearborn

DATE: July 1989

TITLE: Gamma and Induction Logging

INTRODUCTION

Use of borehole geophysical techniques to supplement knowledge of subsurface soil properties gained during drilling, and to provide greater refinement in mapping lithologic contacts, has been documented in an increasing number of investigations in recent years. It is now widely recognized that today's geophysical tools provide a much greater density of unbiased (i.e., without subjective, nonuniform procedures) geophysical measurements than feasible through sample retrieval. Recently, the direct digital recording of individual data readouts at the usual 0.5-foot travel interval and computer processing into composite log suite graphs makes borehole logging a powerful and economical analytical technique for subsurface soil definition.

Interpretation of site geology requires accurate recognition and mapping of soil lithologies which cap have subtle, but important, hydrogeologic differences that may strongly influence contaminant movement. Characterization of various unconsolidated sedimentary strata can be greatly enhanced by logging with the following geophysical probes or methods. Adequate lithologic resolution by these methods can be obtained by logging within PVC-cased wells.

LOG TYPES

Induction Measurements

Induction measurements are collected using a Geonics EM39 logging system that includes a quadrature component of an induced electromagnetic field which can be related to conductivity and an in-phase component which is related to magnetic susceptibility. The tool uses a transmitter coil, a receiver coil, and a focusing coil. It operates at 39.2 KHZ and can be used in the vadose and saturated zone through PVC casing. The focusing coil causes measurement sensitivity to peak at the distance of about 12 inches from the borehole axis. Significant borehole effects should not occur from this tool for boreholes that range from 2 to 8 inches in diameter.

Primarily this tool is used to measure a bulk conductivity that is the combined result of electrical properties of the geologic materials and the contained groundwater. In general, conductivity will increase as clay content increases, as fluid content increases, and as the ionic strength of water increases. It may be difficult to identify contaminated groundwater in sediments that contain variable amounts of clay. In these environments, comparison of conductivity logs to natural gamma logs may enable discrimination between clayey sediments and zones of contaminated groundwater. However, it is important to note that very small variations in clay content may result in large changes in conductivity. These small variations in clay content may not be resolved with the gamma ray log.

Gamma Measurement

The gamma measurement detects natural gamma radiation that occurs in all rocks and is recorded in counts per seconds. This log detects relative changes in radiation and is used for lithologic identification and stratigraphic correlation. Natural occurring radiation comes from three principal areas, potassium 40 which occurs within all potassium minerals, thorium 232 which is associated with biotite, sphene, and zircon-type minerals, and uranium 232. The typical depth of investigation from the natural gamma log is approximately 10-12 inches. In most environments, high gamma measurements indicate the presence of radioactive clay minerals.

DATA ACQUISITION

The borehole geophysical logging equipment, manufactured by EG&G, Mt. Sopris Instrument Company, and Geonics Limited, digitally collects specific probe data onto a Compaq II personal computer. Subsequent processing and display of the data are made with custom software.

Geophysical log data are normally recorded in two modes:

Analog Chart Display - Continuous pen trace recordings of each log type are made with fuller header notations. The traces are depth-synchronized and depth-annotated, within an accuracy of less than 0.5 foot difference between ending depth reading of traces and respective depth dial reading of the logger instrument. (This means that the depth dial reads tenths of a foot.) The parameter scale (horizontal) is plainly labeled as to units of measurement (e.g., counts per second, density in grams/cc, etc.) and margin values. Any mechanical or electrical interruptions or observed spurious activity affecting a log trace is noted opposite the trace deviation.

Digitized Records - To facilitate interpretation of log suites and their presentation in reports, the probe responses are stored on magnetic tape cartridges or computer diskettes simultaneously with the recording on analog charts. The logging system permits such data storage with registered probe depths for each 0.5 foot of well logged. Stored data values are unprocessed. The digitally stored values usually represent the total response pulses counted between two successive recording depths. Alternately, if the electronic control module supplying digital output is equipped with a built-in fixed or adjustable time constant function, averaged values over a specified time interval (e.g., 2 seconds) are recorded.

A processing form is filled out as the raw data are processed. This form contains all of the processing steps and file names. It allows someone not familiar with the data to reconstruct the processing steps including filters used, sampling intervals, trace cutoff depths at fluid level, any merge points, any log calculations, etc. All of the log data are recorded in the simplest form and then corrected, filtered, and processed.

The initial processing step for all of the raw data files is to remove any duplicate depths and any gross bad data. The next step is to select a constant sample interval (i.e., 0.5 ft.), filter any data as necessary to remove random noise (e.g., gamma log), depth align the log traces, and correct the log values to real numbers, if necessary. The separate log files from each run are also merged horizontally into one master data file. The induction logs are often more easily interpreted when presented in conductivity and magnetic susceptibility units.

Digital data processing also consists of correcting depth offsets of the different probe functions, converting conductivity in millisiements per meter to ohm-m, combining individual probe runs to a single file, and cutting off the induction and temperature data just above the water level in the well.

The logs are commonly related on the initial and final wells logged to document correct tool operations. All probes and logging cable can be steam cleaned between probe runs to minimize cross contamination potential from the logging process.

<u>Quality Assurance and Record Keeping</u>

The same equipment is utilized for logging all wells for a given project. All data are recorded in the simplest form and then corrected, filtered, and processed. Additionally, an audit trail (file) can be made that shows the changes made to the raw data. Daily logging summaries are filled out for each day in the field. These records document all equipment serial numbers, when they were used, hole conditions, weather conditions, logging speed, sample interval, equipment operation(s), witness(es), digital file names, etc.

The raw analog and digital data are checked as each hole is logged for correct tool operation. Field prints of the digital data are made on site prior to moving the equipment off the hole and checked for inconsistencies. All of the digital data are backed up onto a secondary storage media prior to moving the equipment off the hole.

Calibration of the logging system/probe types may include the following documentation:

<u>Natural Gamma</u> - Calibration values can be tied to an industry-recognized standard, such as the Department of Energy (DOE) uranium test pits or American Petroleum Institute (API) test pits. Prior to logging each day, a low-level source sleeve, or comparable device, may be placed at the probe detector to verify that it is functioning within 5 percent of the established (documented) calibration value of the field standard (sleeve).

<u>Induction</u> - A zero conductivity can be established under non-humid air conditions by suspending the probe in air away from all conductors. Calibration of resistivity by standard techniques, such as suspending copper hoops of fixed dimension around the probe, may be accomplished prior to logging, and such documentation should be provided by the manufacturer.

LOG INTERPRETATION

A log composite or summary log is made for each well. This composite includes all of the individual well logs and usually a well construction diagram. These log composites facilitate interpretation by presenting all of the log data from one well at a sufficient scale where they can be compared and evaluated together.

Interpretation utilizing geophysical logs is accomplished by first aligning the geophysical logs along a common datum elevation and then assessing the continuity of anomalies from one log to another. The geophysical log responses are then considered based upon their depth of investigation and the apparent well construction effects. Well construction competency, in terms of voids behind pipe and grout backfill uniformity must be assumed to be insignificant, or else lithologic interpretation may require qualifications.

TECHNICAL MEMORANDUM

PREPARED BY: R. Michael Nugent

DATE: July 1989

TITLE: IN-SITU HYDRAULIC CONDUCTIVITY TEST

PURPOSE: The purpose of this technical memorandum is to provide technical guidance pertaining to slug tests. These procedures are intended to establish baseline practices to assist Technical Directors and Site Managers in preparing and implementing site-specific work plans. The procedures as presented are not to be construed as a rigorous standard and slight deviations are anticipated based upon site conditions.

SCOPE: Slug tests are a quick and inexpensive means to estimate the hydraulic conductivity (K) of many aquifers. Slug tests generally work in aquifers where K is less than or equal to 10^{-3} cm/sec. In aquifers with a greater hydraulic conductivity, the water level may return to static level prior to obtaining sufficient time versus head readings. Slug tests are generally a reliable field method to determine hydraulic conductivity in the range of 10^{-4} to 10^{-7} cm/sec.

The advantages of using slug test to estimate hydraulic conductivities are:

(1) Estimates are made in situ and errors incurred in laboratory testing of small or disturbed overburden samples are avoided.

(2) Tests are performed quickly at a relatively low costs in that a pumping well and observation wells are not required.

(3) The hydraulic conductivity of discrete portions of an aquifer can be made.

(4) Treatment and disposal of contaminated groundwater as with a pumping test is not a consideration.

However, there are disadvantages in using slug tests which are to be considered. These include:

(1) Only the hydraulic conductivity of the aquifer in the immediate vicinity of the well is estimated. This estimate, by itself, may not be representative of the aquifer in toto.

(2) Often only a range of hydraulic conductivity values rather than an average estimate can be deduced from test results.

(3) Certain assumptions are made in the analysis process. If geologic and test conditions do not approximate the assumptions, the subsequent results may be erroneous.

(4) The aquifer storage coefficient, S, cannot be determined under most conditions.

(5) As noted previously, there exists constraints in the applicable range for aquifer K values. Beyond these limits the test procedure is either invalid (i.e., $K < 10^{-7}$ cm/sec) or data is difficult to obtain (i.e., $K > 10^{-3}$ cm/sec).

DEFINITIONS:

<ins>Hydraulic Conductivity (K)</ins> - A quantitative measure of the ability of porous material to transmit water. Hydraulic conductivity is depended upon properties of the medium and fluid. Also referred to as "permeability".

<ins>Transmissivity (T)</ins> - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity multiplied by the aquifer's saturated thickness.

<ins>Slug-Test</ins> - A rising head or falling head test. A slug test consists of adding a slug (of water or a solid cylinder) of known volume to the boring or well to be tested or removing a known volume and measuring the rate of recovery of water level inside the well. The slug of known volume acts to raise or lower the water level in the well.

<ins>Rising-Head Test</ins> - A test used in an individual borehole or well within the saturated zone to estimate the hydraulic conductivity of the surrounding formation by lowering the water level in the boring or well and measuring the rate of recovery of the water level. The water level may be lowered by pumping or bailing. Also known as a bail test.

<ins>Falling-Head Test</ins> - A test used in an individual borehole or well to estimate the hydraulic conductivity of the surrounding formation by raising the water level in the boring or well and measuring the rate of drop in the water level. A constant head test is a variation of the falling head test in which water is constantly added to borehole or well to be tested, and the flow rate required to maintain hydraulic head at a constant level above the static water level is measured.

<ins>Packer Test</ins> - A hydraulic conductivity test using inflatable packers to isolate a discrete zone within the borehole for testing purposes.

<ins>Packer</ins> - A sealing device installed in a well or borehole which isolates intervals within the boring or well for testing purposes.

EQUIPMENT:

(1) Electric water-level indicator
(2) Solid or ballast filled "slug" cylinders of 4-inch, 3-inch, and 2-inch diameter each 4 or 5 feet in length.
(3) Single-strand stainless steel on PTFE (teflon) coated line to lower or raise slug
(4) Ten psi, 15 psi, or 25 psi pressure transducer with appropriate length of cable
(5) Data logger for recording pressure (head) changes from transducer
(6) Field notebook
(7) Pen
(8) Five-foot folding, engineer rule
(9) Duct or electrical tape

PROCEDURE:

The test consists of measuring the rate at which the water level within the monitoring well declines after a known volume (slug) is "instantaneously" introduced or the rate at which the water level rises after the slug is removed.

Prior to initiating the test, the following information is to be recorded in the field notebook.

- Test procedure (reference this technical memorandum) plus any deviations from the test procedure;
- Serial number, pressure range, and voltage output range of pressure transducer;
- Well or borehole identification code;
- Location and elevation of measuring (reference) point at which depth to water level measurements are made;
- Date and time of test;
- Well depth, screen length, screen slot size, riser pipe inside radius, well screen inside radius, sand/gravel pack size ranges and borehole radius;
- Aquifer or groundwater zone being tested;
- Slug volume;
- Type of measuring device used; and
- Names of personnel conducting slug test

CONDUCTING THE SLUG TEST:

1. Water level indicator, transducer and cable, and the slug will be cleaned using a nonphosphate detergent wash and a distilled water rinse followed by a pesticide grade isopropanol rinse and allowed to air dry. Prior to use, the equipment shall undergo a distilled water rinse. Water level indicator probe shall be cleaned after each use.

2. Wells will be opened, allowed to equilibrate, and depth to water level measured and recorded.

3. A slug will be selected based on well diameter and a line attached. The line will be marked at a distance from the bottom of the slug equal to the measured depth to water level plus the length of the slug.

4. The transducer will be lowered into the well to a depth of 10 feet below the static water level or as close to this depth as allowed by well/water level configuration. (Note: Pressure transducer must lie at least 2 feet below the depth of the slug to dampen pressure waves and must be at least 1 foot above the bottom or sump section of the well to prevent silting.) Tape the pressure transducer to the well casing to fix the depth of the transducer in the well.

5. The following is specific to operation of the Model EL-200 data logger.

   (a) Function B0 - Enter a two digit station ID number (00-99) and press <E> (Enter).
   (b) Function B1 - Enter the date in format YY/MM/DD and press <E>.
   (c) Function B2 - Enter time in format HH:MM:SS and press <E>
   (d) Function B4 - Press <E> until appropriate pressure transducer channel is reached and enter appropriate scale factor for transducer. Press <E> and then <F>.

Analog Channel Scale Factors (s/f)

S/F	0%	100%	1 LSB	Remarks
000	--	--	--	Channel is off.
001	0.000	2.307	.001	Input in psi
002	0.000	4.61	.01	Scaled output (ft)
005	0.000	11.53	.01	
010	0.000	23.07	.01	
015	0.000	34.60	.01	
025	0.00	57.67	.01	
050	0.00	115.3	.1	
100	0.00	230.7	.1	
250	0.00	576,700	.1	

(e) Function B6 - Check probe calibration by raising transducer in 0.5 foot intervals. Record depth to probe (below water surface) and displayed values.
(f) Function A3 - Places data logger in SILOG II status.
(g) Function 5 - Editing SILOG II Segments.
(h) Press 01200001 then <E> - will result in readings being taken at 1 second intervals (01200001) for 120 seconds (01200001).
(i) Press 00360005 then <E> will result in readings being taken at 5 second intervals for the next 3 minutes (i.e., 36 5-second intervals).
(j) Press <F> to exit editing mode

6. Lower the slug until the static water level is reached and then raise slug slightly above this mark. Secure slug line to well casing leaving sufficient slack so that slug can be completely submerged when test begins.

7. Press <3> then <B> to start data logger and after 5 seconds lower slug into water. Slug must be lowered into water as quickly as possible. However do not allow slug to drop into the water but glide it in. This will prevent compression waves and faulty readings during the initial part of the test.

8. Press any key and then <B6> to display pressure head readings.

9. Upon termination of the test and the return of the water level to static conditions, press <A3>, <3>, <B> then wait 5 seconds, and remove slug. This begins the rising head portion of the test.

10. Press any key and then <B6> to display pressure head readings. Terminate test when pressure head reading indicates 90 to 100 percent recovery.

11. Press any key and then <AC> to power down. Remove power cord.

12. Decontaminate slug, pressure transducer, and slug line as outlined in Step 1.

NOTE: (A) For situations where static water level is within screen interval, only perform the rising head portion of the test.

(B) RAM only holds 12,000 data points.

DATA ANALYSIS:

The analysis of slug test data is based on the modification of well known groundwater flow equations (either the Theis equation, the Theim equation, or subsequent modification). Several authors have presented analytical solutions for the analysis of slug test data. Most solutions require a semi-logarithmic plot of the data collected: dimensionless head (logarithmic scale) or residual head (logarithmic scale) versus time (arithmetic scale).

Hvorslev (1951) was one of the first researchers to publish techniques of analysis of either constant or slug (falling head) tests in near-surface saturated soils. His analysis of slug tests involves a semi-logarithmic plot of the falling head (or water level) divided by the initial head against time. Basic algebraic equations are presented for different configurations of the soil relative to the test hole. In general, the permeability is proportional to a "shape factor" and inversely proportional to a "time lag." The "shape factor" is determined from the test well characteristics or dimensions. "Time lag" is determined from the semi-logarithmic plot.

Cooper et al. (1967) and Papadopulos et al. (1973) developed a set of type curves for analyzing slug test data, particularly for tests run in materials which are confined (under artesian pressure). The field data are plotted as dimensionless head (arithmetic scale) versus time (logarithmic scale) and matched to a set of type curves. The match point values are substituted into simple algebraic formulations to obtain a value for K.

Bouwer and Rice (1976) and Bouwer (1978) developed a technique for analyzing slug test data collected from completely or partially penetrating wells in unconfined aquifers. Their analysis involves a plot of residual head (logarithmic scale) versus time (arithmetic scale). A straight line is applied to the early-time data and used to calculate a value for K.

Pressurized slug test methods have been developed for testing extremely low hydraulic conductivity (10^{-8} cm/sec or lower) materials (Bredehoeft and Papadopulos, 1980). Basically, the pressurized slug technique is a modification of the conventional slug test previously discussed. The advantage of the pressurized slug technique is the reduction of time required to perform a test in tight formations. This method involves creating an instantaneous pressure surge on drawdown in the test zone, then closing a valve to shut in the well. Based on the rate of decay of the pressure slug and the geometry of the test zone, the transmissivity, hydraulic conductivity, and storativity may be calculated.

TECHNICAL MEMORANDUM

PREPARED BY: Williams & Associates

TITLE: IN-SITU GROUNDWATER SAMPLING - THE BAT SYSTEM

INTRODUCTION

The BAT System consists of two basic components: (1) a well point which is pushed into the ground to a specific target depth via the cone penetrometer's hydraulic system; and (2) a sampling device which allows for a sample to be obtained in a closed system and equilibrated to in-situ pore fluid pressure. The push-rod is specially designed to seat itself without the use of O-rings. The inner rod is thereby unexposed to groundwater. The BAT tip is designed to allow formation fluids to flow into a small chamber which is sealed from the inner rod by a water tight seal.

A hermetically sealed evacuated vial is lowered into the push rod through the use of weighted, sampling assembly. The assembly mechanism contains a double-ended hypodermic needle which first pierces the well tip seal, followed immediately thereafter by the vial seal, located in the vial screw cap. Formation fluids are drawn into the vial until the pressure in the vial is equivalent to the formation pore fluid pressure. When the sampling assembly is pulled from the rod tip, the needle is pulled from both disks, and both the vial and tip are re-sealed.

Thus, a sample is obtained in a closed system, with little opportunity for cross-contamination, human contact, volatilization, or chemical changes due to Eh-pH changes resulting from exposure to surface pressures or the atmosphere. Although some headspace will exist in the vial, this headspace is equivalent to the pore fluid pressure and research has shown that the sample integrity is greater than if sampled by more conventional methods, such as a manual bailer (Blegen, Hess, and Denne, 1988). Additionally, only one vial volume (or less) is required for purging the system, versus relatively large volumes required by conventional methods. Disposal of wastewaters as well as waste soils are therefore not an issue when using this system.

The BAT System sample probe can be left in place; however, for most studies the system will be retrieved and the holes grouted. Analytical results can be provided on site via the BAT sampling system and a portable gas chromatograph. These tools will provide essentially instantaneous data for use in evaluating the character and extent of a contaminant plume. Use of the system in this manner will allow for more cost effective well placement by eliminating useless well locations and will greatly expedite the contamination assessment process.

DECONTAMINATION

Decontamination of the cone penetrometer and BAT Sampling systems rods can be accomplished in two ways. For sites where contamination provides minimal health concern, the rods are removed from the ground and transported to a decontamination area, where they are steam cleaned. If necessary, an Alconox bath followed by a distilled water and isopropanol rinse can follow the steam cleaning procedure.

For sites where potential contaminants pose greater concern, the rods can be decontaminated in a similar fashion to that described above, as they are being pulled from the ground. A decontamination tub can be utilized to catch all decon wastewater for subsequent transport or evaporation.

The decontamination tub is constructed of aluminum and is oval shaped. The height of the tub is of such an elevation that it can be placed underneath the cone penetrometer rig during operation. The center of the tub contains a neck or collar, which rises from the bottom of the tub upwards and allows the push rod to pass through the bottom of the tub and into the ground. Upon completion of the push procedure, the push rod can be steam cleaned by utilizing a plastic curtain around the tub which directs all wastewaters into the tub. Wastewaters are prevented from flowing downward along the rod and back into the hole by use of a rubber ring which fits tightly around the rod, and is larger in diameter than the metal collar.

The BAT sampling tip is decontaminated by first removing the used filter as well as the rubber septum located in the upper portion of the tip. The BAT tip is then placed back onto a push rod section which allows both the inside and the outside of the sampling tip to be steam cleaned. Following steam cleaning, the tip assembly is placed in an isopropanol bath, followed by a distilled water rinse. Next a new filter is placed on the tip and the tip assembly is placed in a distilled water bath within a stainless steel pressure cooker. The pressure cooker is closed and the tip assembly is "cooked" on a high setting until the temperature of the water well exceeds its boiling point. Following this procedure, the tip assembly is placed into a stainless steel container of cool distilled water at which time a new rubber septum is placed in the upper portion of the tip (while under water)

The boiling process described above insures that the filter material (15 micron high-density polyethylene) is fully saturated prior to placement in the ground to assure a good hydraulic connection. The tip mechanism contains a chamber of approximately 10 milliliters in volume. The first sample vial is used to purge the tip of the distilled water. Subsequent to the acquisition of the first vial, the following vial can be used for sample analysis. All rods and sampling tools are handled using new surgical gloves or appropriate decontaminated tools.

EQUIPMENT

The in-situ BAT System consists of three basic components:

(a) a permanently installed, sealed filter tip which is attached to an extension pipe,
(b) a disposable, double-ended hypodermic needle, and
(c) a pre-sterilized, evacuated sample vial of glass.

Both the filter tip and the sample vial are sealed with a specially developed septum. The vial is mounted in a portable sampling probe together with the needle. When lowered down the extension pipe, the probe connects to the cap of the filter tip, causing the ends of the needle to penetrate the septa in the tip and the sample vial, respectively.

The hypodermic needle provides a temporary, leakproof hydraulic connection between the filter tip and the sample vial. Due to the vacuum in the vial, groundwater is drawn from the formation via the filter tip into the vial.

Some fluid must be purged from the system prior to actual sampling. However, since the tip is in direct contact with formation fluids, and contains only a very small volume itself, the amount required to be purged is also minimized.

When the probe is disconnected from the filter tip, the septa in both the filter tip and the sample vial automatically reseal. A special mechanism causes the needle to first be disconnected from the sample vial, ensuring no loss of sampled fluid or pressure. Tests have shown that the septum in the filter tip can be pierced hundreds of times without loss of its automatic self-sealing capability.

The basic in-situ system is designed for 1-inch nominal inside diameter extension pipes, and permits use of sample vials having a volume of 35 ml. By use of larger diameter pipes (for example 1-1/2 inch or 2-inch) the sample volume can be increased to between 150 and 500 ml.

There are also a number of special add-on adapters which facilitate use of the in-situ sampler. For instance, sample vials can be cascaded using double-ended vials. Both two- and three-vial chains have been tested.

To aid metals analysis, an adapter carrying a 0.2 or 0.45-um pore-size Millipore filter may be inserted between the transfer device and the sample vial. Injection of a minute amount of acid into the evacuated vial just prior to sampling can also aid sample preservation for such analyses.

Filter tips - BAT filter tips have been developed in a variety of configurations and material.

1. The standard filter tip has been designed with special consideration given to requirements for both high chemical inertness and adequate mechanical strength. It has a body of thermoplastic and a filter of high-density polyethylene, sintered ceramic, or porous polytetrafluoroethylene (PTFE). The ceramic filter has an air entry value which permits sampling and pressure measurement in the vadose zone.

2. The stainless steel (ASTM 316 H) tip provides additional installation strength.

3. The heavy-duty tip has its filter molded inside the body of stainless steel or brass. This tip is designed for use in coarse soils such as gravels and tills.

4. The probe tip is used for special purposes, for example, sampling and pressure measurement in thin soil layers.

As was mentioned above, a filter tip is attached to an extension pipe, and is normally installed by pushing it under a static load down to the desired depth. The heavy-duty tip can be driven into the soil using a light hammer. Installations can also be made in predrilled holes.

PROCEDURE

1. Decontamination of all extrusive equipment shall be carried out prior to each exploration. Decontamination procedures are presented in the section entitled DECONTAMINATION.

2. Install filter tip, attached to the appropriate length of extension rod, to the desired depth.

3. Evacuate the hermetically sealed, pre-sterilized sample cylinder prior to attaching to the sampling adapter.

4. Lower adapter down extension pipe until adapter connects with nozzle of filter tip; thus allowing double-sided hypodermic needle to penetrate both the septum in nozzle and the septum in sample cylinder.

5. Allow sufficient time for sample cylinder to fill. Time requirement is a function of hydraulic conductivity, pressure head, and vacuum in sample cylinder.

TECHNICAL MEMORANDUM

PREPARED BY: R. Michael Nugent

DATE: August 1989

TITLE: AQUIFER PUMPING TEST

PURPOSE

The purpose of this technical memorandum is to describe the use of aquifer pumping tests to evaluate aquifer hydraulic characteristics. These procedures are intended to establish baseline practices to assist project personnel in preparing and implementing pumping tests. The procedures as presented are not to be construed as a rigorous standard and deviations are anticipated based upon site conditions.

SCOPE

Aquifer hydraulic characteristics that can be obtained from pumping tests include hydraulic conductivity (K), transmissivity (T), specific yield (Sy) for unconfined aquifers, and the storativity (S) of a confined aquifer.

Equipment, personnel, and time requirements for pumping tests can be significantly greater than those required for single-hole permeability tests. Hence, planning for a pumping test is a significant component.

A pumping test consists of pumping one well at a constant discharge and recording the drawdown in one or more observation wells. The advantages of a pumping test include:

- A large portion of the aquifer can be tested and the subsequent results are typically more representative of the average hydraulic characteristics.

- Storativity and specific yield values can be determined.

Disadvantages of pumping tests are:

- In low permeable aquifers (K $>10^{-7}$ cm/sec) a long-term pumping (i.e., weeks to months) will be necessary to provide sufficient data for analysis.

- Contaminated groundwater discharged during pumping will require treatment or must be permitted for discharge.

- Labor, equipment, and time intensive.

DEFINITIONS

Hydraulic Conductivity (K) - A quantitative measure of the ability of an aquifer to transmit water. Hydraulic conductivity is depended upon properties of both the porous medium and the fluid. Also referred to as "permeability."

Transmissivity (T) - The product of the hydraulic conductivity and the saturated thickness of the aquifer.

Storativity (Storage Coefficient) (S) - Volume of water that confined aquifer releases from or takes into storage per unit area of aquifer per unit change in head, nondimensional.

Specific Yield (Sy) - The volume of water released from or added to storage in an unconfined aquifer per unit horizontal area of aquifer per unit decline or rise of the water table.

Specific Capacity (Cs) - Rate of yield per unit drawdown in a pumping well.

Drawdown (s) - Difference at a point between the elevation of the non-pumping potentiometric surface and the water level elevation at some position during pumping.

Discharge (Q) - Volume of water removed per unit of time.

Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

Confined Aquifer - An aquifer that is overlain and underlain by zones of lower hydraulic conductivity. If the aquifer is "artesian," the potentiometric head of the aquifer at that point is higher than the top of the zone comprising the aquifer at that point.

EQUIPMENT

1. Pumping well and pump. The pumping well should be fully developed prior to the pumping test.

2. One or more observation wells which are hydraulic connected to the aquifer to be pumped and completed to the specification of the particular pumping test.

3. A calibrated orifice, weir, flow meter, or other means to accurately measure the discharge from the pumping well.

4. Sufficient discharge pipe to transport pumping well discharge to an area outside the influence of the pumping well.

5. Gate valve on the discharge line to control pumping rate.

6. Outlet near well head to determine water quality parameters or collect a groundwater sample.

7. Depth to water measuring device for each observation well. Measuring devices may include steel tape, electric probes, water level recorders, or pressure transducer.

8. Field water quality testing equipment. At a minimum this shall include a specific conductance meter, pH meter, and temperature probe. Additional equipment may include, specific ion probes, Eh probe, field gas chromatograph, etc. and will be used as required in the work plan.

9. Watches for each field personnel capable of reading to the nearest second.

10. 3-Cycle by 5-cycle log-log paper and 5-cycle semi-log graph paper.

11. Ball-point pen and field notebook or appropriate pumping test data sheet.

12. Appropriate references and calculator for calculations in the field.

13. A barometer or recording barograph.

PROCEDURE

General. There are several types of pumping tests. The most common type is the constant rate discharge test (Todd, 1981). Variable rate tests are also employed under some conditions. Although the analysis is more complicated, any sort of temporal variations in flow rate can be accounted for by assuming the law of superimposition holds. Usually this a good assumption. The most widely used variable rate tests are the step-drawdown test, the constant head test, and the air-lift pump test (Kruseman and DeRidder, 1976).

Another useful technique is injection testing. Injection tests, both constant rate and variable rate, are analytically identical to pumping tests except the flow rate is a surcharge on the aquifer rather than a withdrawal. The data quality is also similar. Although injection tests are commonly used in the petroleum industry (Earlougher, 1977), numerous applications exist in hazardous waste practice. Obviously, water sampling for hydrochemical characterization of the aquifer must be conducted prior to injection (or considered unimportant) in application of this technique. The injection fluid should be free of suspended solids and should be of equal or higher quality than the groundwater at the test site.

One major advantage of the injection test is that contaminated groundwater is not removed from the formation and, thus, posed no disposal problem. A potential disadvantage of the injection test is that in certain cases the injection well would have to be able to withstand some induced hydraulic pressure. Cases where the injection rate is large enough to elevate the water level above the well casing would require a sealed well head configuration and proper well construction so that there would be no leakage of injection fluid on the ground surface. These requirements may be relatively expensive and difficult to operate in the field without the necessary precautions. Once an injection system is working at a constant rate of flow, the data collected are analyzed in much the same way as those from an aquifer pumping test, except that water level buildup is used in the analysis instead of drawdown.

This technical memorandum briefly describes equipment, procedures and other factors which must be considered for constant-rate pumping tests. References which provide additional information are presented in the list of references. Ground Water and Wells (Driscoll, 1986) is a field guide with may suggestions on how to perform the test. Ground Water Hydrology (Todd, 1981) and other references such as Kruseman and DeRidder (1976) provide analytical techniques and example problems of pumping tests conducted under different geologic conditions.

The determination of aquifer characteristics from the pumping test data by graphical methods is most common. Most methods are derived from Theis nonequilibrium formula. The assumptions inherent in the formulas used in calculating the aquifer characteristics must be evaluated to insure validity of the formula under the actual conditions at the site being investigated.

PUMP WELL DESIGN

Design of the pump well is an important consideration in aquifer testing. In some cases an existing well will be used for pumping. When sufficient funds and conditions permit, a pumping well can be designed and constructed specifically for the test. The pumping well should be screened throughout the thickness of the aquifer to be tested with standard well screen. The well should be gravel packed, if necessary, to minimize sand production in unconsolidated fine-grained aquifers. Standard well construction techniques are discussed in Driscoll (1986). The well should be correctly sealed from overlying and underlying units that are not directly pumped so that leakage down the well annulus cannot occur and interfere with the interpretation of the test. The completed pumping well should be developed by the appropriate methods to remove drilling fluid from the well and to wash and grade the grain sizes of the gravel pack and surrounding aquifer materials. Proper development of the well may prevent an unexpected variation in the pumping rate during the constant discharge test which, if the variation occurred, could lead to inconsistent drawdown data from the pumping well.

SITING OF OBSERVATION WELLS

The location and number of observation wells depends on several factors:

- Whether the aquifer tested is confined or unconfined;
- The thickness of the aquifer;
- The anisotropy of the aquifer;
- Location of the screened interval of the pumping well relative to the total aquifer thickness.
- Location of aquifer boundaries, whether positive (lake or stream) or negative (impermeable boundaries); and
- Practical and economic considerations.

Any number of observation wells may be considered. Often, four wells are desirable, three on a line passing through the center of the pumped well and one on a line normal to that line and also passing through the pumping well. A number of guidelines for location of observation wells are presented in the Ground Water Manual prepared by the U.S. Department of Interior and Kruseman and DeRidder (1976).

As a general rule for tests performed in both confined and unconfined aquifers, the observation wells should be screened or completed in a substantial portion of the aquifer thickness in approximately the median depth of the test zone. In some cases, special tests require that observation wells be selectively completed in several depth zones in order to accurately determined aquifer characteristics such as anisotropy and vertical hydraulic conductivity.

The location of the observation well from the pumping well is, in part, controlled by the aquifer conditions: whether they are confined or unconfined. The location of observation wells generally depends on four aquifer conditions:

- Most aquifers with fully penetrating pumping wells: observation wells should be located at a distance estimated by using the Theis formulation (Theis, 1935). Use of this formulation is described by Walton (1970). Assumed aquifer parameters are used to determine a location which will give the amount of drawdown required for proper analysis.

- Thin aquifers with fully penetrating wells: for confined aquifers the nearest observation well should be located at least 25 feet from the pumping well. For unconfined aquifers, observation wells should generally be located 15 to 100 feet from the pumping well.

- Thick, isotropic aquifers with a partially penetrating pumping well: observation wells should be located one and one-half to two times the aquifer thickness from the pumping well.

- Thick anisotropic aquifers with partially penetrating well: observation wells should be located at a minimum distance from the pumping well equal to twice the thickness of the aquifer times the square root of the ratio of the horizontal to the vertical hydraulic conductivity.

PROCEDURE

Preparation for Test. For a few days before starting a pumping test, water levels in the pumping well and observation wells should be measured at about the same time each day to determine whether there is a measurable trend in groundwater levels. If such a trend is apparent, a curve of the change in depth versus time should be prepared and used to correct the water levels read during the test.

Pumping wells should undergo preliminary pumping prior to the actual test. This will enable fines to flushed from the formation and a steady flow rate to be established. The preliminary pumping should determine the maximum drawdown in the well and establish the pumping rate for the later test. Step-drawdown testing should be performed to determine the proper pumping rate for the long-duration pumping test to follow. The aquifer should then be given time to recovery before the pumping test is begun.

Barometric changes may affect water levels in wells, particularly in confined aquifers. An increase in barometric pressure may cause a decrease in the water level. Any change in barometric pressure during the test should be recorded, in order to correct the water level measurements taken during the pumping test, if required.

A record should be maintained in the field notebook of the times of pumping and discharge of other pumping wells in the area, if their radius of influence intersects the cone of depression of the aquifer pumping test well. All measurements and observations should be recorded in a field notebook or on the appropriate forms.

In areas of severe winter climate, where the frostline may extend to depths of several feet, pumping tests should be avoided during the winter where the water table is less than about 12 feet from the surface. Under some circumstances, the frozen soil acts as a confining bed, combining with leaky aquifer and delayed storage characteristics that may make the results of the test unreliable.

CONDUCTING THE PUMPING TEST

The field procedures to conduct pumping tests are similar. The basic procedure consists of monitoring the water level over time in the pumping well and each observation well as the pumping well is discharged at a constant rate.

The following data must be recorded accurately at the time the test is performed:

- Well identification number or location of pumping well and each observation well;
- Location and elevation of each well;
- Location and elevation of reference point from which water depth measurements are made and elevation of ground with respect to the reference point;
- Date and time of test; and
- Well depth, pump depth, screen length, well radius, and radius of gravel pack plus well screen for each well.

All gauges, transducers, flow meters, etc. used in conducting pumping tests should be calibrated before use at the site. Copies of the documentation of instrumentation calibration should be obtained by the hydrogeologist and later filed with the test data records. The calibration records will consists of laboratory measurements and, if performed, any on-site zero adjustment and calibration. In cases where a weir or an orifice is used to measure flow rates, the device will be checked on site using a container of measured volume and stopwatch. Accuracy of the meters must be verified before testing proceeds.

Immediately prior to the pumping test, the static water level in each observation well shall be measured and recorded with the time of observation in either the field log book or onto an appropriate data sheet.

Water pumped from an unconfined aquifer during a pumping test shall be disposed of in such a way so that the aquifer is not recharged by infiltration during the test, as recharge would influence the results obtained. Also, if contaminated water is pumped during the test, the water must be stored and treated or disposed of in an acceptable manner. The discharge could be temporarily stored in drums in a lined pit, or tanks. If necessary it should be transported and deposited in a designated secure area.

During an aquifer test, water levels should be measured to give at least 10 observations of drawdown within each log cycle of time. During the early part of the test, sufficient personnel should be available to have at least one person at each observation well and at the pumping well. After the first 2 hours, two people are usually sufficient to continue the test. It is not necessary that readings at the wells be taken simultaneously. It is very important that depth to water readings be measured accurately and readings recorded at the exact time measured. A schedule for measurements is as follows:

0 to 10 minutes	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4, 5, 6.5, 8, and 10 minutes (It is important in the early part of the test to record with maximum accuracy the time at which readings are taken).
10 to 100 minutes	10, 15, 20, 25, 30, 40, 50, 65, 80, and 100 minutes
100 minutes plus	At 1- to 2-hour intervals, to completion.

During the course of the pumping test, well discharge should be measured frequently and should be controlled to maintain as much of a constant discharge rate as possible. Attention also must be given to the pump engine to check performance. Changes in tonal quality is indicative of a change in pump discharge rate.

The total pumping time for a test depends on the type of aquifer and degree of accuracy desired. Economizing on the period of pumping is not recommended. More reliable results are obtained if pumping continues until the cone of depression reaches a stabilized condition. The cone of depression will continue to expand at a slower rate until recharge of the aquifer equals the pumping rate and a steady-state condition is established. The time for steady-state flow to occur may vary from a few hours to years.

Under average conditions it is good practice to run a pumping test in a confined aquifer for at least 24 hours and in an unconfined aquifer for a minimum of 72 hours. A longer period of pumping may reveal the presence of boundary conditions not previously known. Preliminary field plotting of drawdown data should be conducted during the test to monitor how the test is progressing and how much longer it should be continued. If time or budget constraints preclude long-term pumping tests, shorter term tests, 2 to 4 hours in length, can be used to estimate aquifer characteristics in some cases. Drawdowns may not be noted in observation wells during short-term tests, so discharge/drawdown data from the pumping well is critical.

RECOVERY TEST

When the pump is stopped at the conclusion of the pumping phase, the drawdown and time at which it was shut down are recorded on the Data Sheet for Aquifer Tests. The rate of recovery of the water level in the wells will then be measured. The same procedure and time pattern for taking water levels is followed at the beginning of a test.

The recovery data should be recorded until water levels stabilize, or as long as possible within project constraints.

DATA ANALYSIS

Numerous techniques of analysis have been developed by researchers to evaluate water-level data collected from constant discharge aquifer pumping tests. Many of the analyses use the graphical "curve matching" technique which involves the matching of theoretical "type" curves to plots of log-drawdown versus log-time from the observation wells. Other analyses rely on other graphical techniques such as application of a straight line plots of drawdown versus log-time.

Theis (1935) developed a theoretical formulation for the lowering of the potentiometric level in an aquifer due to the constant withdrawal of water from the aquifer. This classic formulation has been widely used to predict water level response in aquifers due to specified pumping stresses. Several authors have described the use of this formulation in estimating transmissivity and storativity from aquifer test data: e.g., Lohman (1970), Walton (1970), Todd (1981), and Freeze and Cherry (1979). In brief, the method involves superimposing the Theis solution (or "type" curve) on a log-log plot of drawdown versus time data from a test well. The coordinate axis of the type curve must be kept parallel to the field data plot axis. Data from the "match point" is used to solve two algebraic equations which give the value of transmissivity (T) and storativity (S) (or storage coefficient). Hydraulic conductivity (K) may be computed by dividing T by the aquifer thickness (b).

The same aquifer parameters can also be determined from a semi-log plot of drawdown versus time for either the pump well or observation wells. Cooper and Jacob (1946) showed that at a relatively short time after pumping begins an analysis of the data, plotted as described above, provided essentially the same T, S, and K values as the Theis technique.

Hydrogeologic judgment should be used in applying straight (Cooper-Jacob method) fits to these plots because different hydrogeologic conditions can produce similar trends in the data plot. For example, bounded aquifers produce straight line trends that may yield apparent transmissivity values that are too low. Knowledge of the hydrogeology of the area and the type of aquifer conditions is essential for correct analysis of test data.

Since the development of the Theis equation, several other formulations have been published which attempt to describe the response of certain aquifers to a constant pumping stress. Hantush (1955, 1956) developed formulations and a corresponding set of type curves for an aquifer overlain and/or underlain by a confining bed which has significant storage and experiences vertical flow when the adjacent aquifer is pumped. The same curve matching procedure is used here as with the Theis type curve except that several type curves are available for matching to the data depending on the degree of leakage into the pumped aquifer. Hydraulic parameters of the confining unit can be calculated using the set of Hantush type curves.

Another commonly used set of type curves was developed by Boulton (1954, 1963) and are used when the aquifer tested is unconfined and may exhibit a phenomenon known as delayed yield. Delayed yield is a result of retardation of drainage due to such forces as capillary tension. Boulton's type curves include a set of early-time data and late-time type curves. The early-time data and late-time data are respectively matched to the early-time and late-time type curves to give values for transmissivity, storage coefficient, and specific yield. The particular curve used in the set of "type" curves yields additional information concerning how the unconfined aquifer responds to pumping. Neuman (1972, 1974, 1975) also developed a set of type curves for the response of unconfined aquifers to pumping but used different assumptions concerning the physical processes in effect. In practice, Neuman and Boulton curves have been shown to give similar results.

Other less common analytical techniques have been described in detail by the authors mentioned above. A publication by Kruseman and DeRidder (1976) is one of the most complete works on the analysis and evaluation of pumping test data. Methods described (with practical examples) include treatment of aquifers from confined to unconfined under both non-steady and steady-state pumping conditions. Methods of correcting drawdown data from tests in which partially penetrating wells exist is also discussed by Kruseman and DeRidder (1976). In addition, the analyses of data from aquifers which have a non-ideal shape or are bounded in some fashion by different hydrogeologic units are presented. Techniques for analysis of recovery data collected after the completion of pumping are presented. Analyses for various types of variable discharge rate tests, such as the Aron-Scott method, are also presented in Kruseman and DeRidder (1976).

TECHNICAL MEMORANDUM

TITLE: Procedures for the development of groundwater monitoring wells.

Author: K.L. Busen Principal Hydrogeologist

Reviewed By: R.M. Nugent Principal Hydrologist

Approved By: ______________________________

PURPOSE: Development of groundwater monitoring wells are performed to remove all the drilling fluids from the borehole and the mud cake from the wall of the borehole and to create a graded zone of sediment (filter pack) around the screen. Proper well development is necessary to achieve ambient groundwater quality in the well and infiltration sand-free water at the approximate specific capacity of the natural formation.

SCOPE: The procedures outlined in this document should be followed in developing a monitoring well after well drilling and installation or in the re-development of a well prior to collecting groundwater samples or conducting aquifer testing.

REQUIREMENTS:

The monitoring well should be properly installed. If grout was used in the installation of the well and the grout extends below the potentiometric surface of the groundwater a period of not less than 12 hours is required for the grout to cure before developing the well. For wells where the grout does not extend to the water table (eg. gas station monitoring wells where the screen is placed above the water table) then well development can take place immediately after the installation of the well providing the grout at land surface is protected from the purged groundwater.

EQUIPMENT: Proper equipment should be selected based on the monitoring well conditions. This section will discuss the equipment that should be used for various field conditions and the procedures that are necessary to operate the equipment and to develop the well under various conditions.

<u>Monitoring Wells</u>. Development of monitoring wells where no unusual conditions exist generally requires fitting the pumping equipment to the diameter of the well and the amount of lift required.

<u>Lift</u>. Suction pumps such as centrifugal and peristaltic pumps are restricted to 1 atmosphere of lifting capacity (33.9 feet of water at 4 degrees C), however, because of frictional head loss, the maximum lifting capacity of these pumps is approximately 20 to 22 feet of head. Push pumps such as submersible pumps, bladder pumps, and most manual pumps have a much greater

lifting capacity. Other pumping techniques that are not restricted by depth include air lifting and bailing.

Well Diameter. Any of the currently available pumping equipment can be used for bailing a 4-inch or greater diameter well. Restrictions that will apply to monitoring wells with a diameter less than 4-inches is the diameter of the pumping equipment (particularly submersible pumps). Considerations for choosing the proper pump should be the well diameter, the pumping rate, and the volume of water that will be required to develop the well. A list of the pumping equipment that can be used for developing wells includes:

- submersible pumps (various diameters),
- centrifugal and trash pumps (high groundwater),
- peristaltic pumps (high groundwater),
- pneumatic pump (air source generally required),
- bladder pump,
- air lifting equipment (hoses, eductor casing, air compressor),
- manual pumps (B-K pump, WaTerra pumps), and
- bailers.

Contaminated Monitoring Wells. A heavily contaminated monitoring well requires unusual precautions. In some situations pumping equipment must be used to develop these wells with the understanding that the equipment can never be used in other monitoring wells. This scenario must be discussed and approved by the Project Manager before sacrificing equipment.

For contaminated wells, it is best to use equipment that can be decontaminated easily or is disposable. Pumping equipment that meets this criteria are:

- bailers,
- air lifting equipment (hoses, eductor casing),
- centrifugal pumps, and
- manual hand pumps (B-K pump, WaTerra pumps).

Restrictions on the pumping equipment are that centrifugal pumps can only be used in wells where the potentiometric surface of the groundwater is less than 20 feet. Bailers, air lift technique, and manual pumps can be used in most wells.

Submersible pumps should not be used for developing heavily contaminated wells.

Note: Special procedures will be necessary for the handling, treating, and disposal of the contaminated groundwater that is purged from the well during well development.

Wells Containing Large Amounts of Sand and Silt. Wells that contain a large amount of fines (sand and silt) require pumping equipment that can pump this material. Submersible pumps and "Keck" pumps should not be used for developing wells that will produce a significant amount of sands and silts.

For these wells, it is best to use equipment that can be easily dismantled or are unaffected by sand and silt. Pumping equipment that meets this criteria are:

- bailers,
- air lifting equipment,
- centrifugal pumps and trash pumps,
- pneumatic pumps, and
- manual hand pumps (B-K pump, WaTerra pumps).

Restrictions on the pumping equipment are that centrifugal pumps and trash pumps can only be used in wells where the potentiometric surface of the groundwater is less than 20 feet. Bailers, air lift technique, pneumatic pumps, and manual pumps can be used in most wells. Other restrictions include the physical effort necessary to use the equipment (eg. air lifting equipment requires a two-person crew).

PROCEDURES:

Overpumping. The simplest method of well development is by overpumping, that is, pumping at a higher rate than the well can recharge. Overpumping, by itself, seldom produces full stabilization of the aquifer and filter pack. Overpumping may compact finer sediments around the borehole and thereby restrict flow into the screen. It is, therefore, recommended that some form of agitation be performed along with overpumping. Agitation or backwashing cause reversals of flow through the screen openings that will agitate the sediment, remove the finer fraction, and then rearrange the remaining formation particles. Backwashing also breaks down bridging in the filter pack. Agitation can be accomplished through surging of the well by turning the pump on and lifting a column of water to the top of the well, then shutting the pump off and letting the water fall back into the well (used with pumps that do not have check valves). By overpumping and periodically surging the well, the filter pack is developed to allow a minimal amount of sands into the well and the drilling fluids and mud pack is broken up and removed from the borehole and surrounding formation. Air lift pumping should be allowed to continue with periodic surging of the well until the well is sufficiently developed. The overpumping and surging technique are performed with submersible, centrifugal and pneumatic pumps.

Manual pumps and bailers can be used to overpump wells with smaller recharge; however, adequate surging may not be accomplished. Surging of low yield monitoring wells can be performed by adding clean water into the well to backwash the screen and filter pack. Factors must be considered, however, whenever adding something to a well (including clean water) to ensure that the added substance will not affect the water quality or jeopardize the purpose of the well. A general rule whenever water is added to a well is to remove at least 150 percent of the volume of added water from the well.

Well Development by Air. Pumping and surging of a monitoring well by air is another method of well development. This practice has increased with the increase of air compressors on drilling rigs. In this method, air is injected into the well to lift the water to the surface. Surging of the well is accomplished by shutting the air supply off when the water reaches the top of the well. The aerated water column falls back into the well causing backwash of the screen, filter pack, and surrounding formation. This is the best method for surging a well. It is also the best method for removing large amounts of sand and silt from wells. Air lift pumping should be allowed to continue with periodic surging of the well until the well is sufficiently developed.

Factors to consider when using this method are as follows.

1. Compressed air in most air compressors is generally derived through the use of an oil bath. Many of these air compressors (particularly old compressors) release a significant amount of oil with the compressed air. This oil could contaminate the monitoring well. Filters are available to remove over 99 percent of this oil and on new compressors, the amount of released oil is a small amount. Most air compressors do not have this filter (particularly rental companies that have older compressors that release a large amount of oil).

2. The use of compressed air will aerate the water in the well and if the air is released in the screened zone, will push air into the surrounding formation. The aerated water and air in the surrounding formation could cause changes to the ambient groundwater quality.

A method to avoid the release of air into the screened zone is to use an eductor casing. An eductor casing is a casing that is of smaller outside diameter than the inside diameter of the well casing. The eductor casing is placed inside the well to just above well bottom. The air line is placed inside the eductor casing so the end of the line is approximately 5 feet above the bottom of the eductor casing. The air supply is slowly turned on to lift the water inside the eductor casing and create a suction at the bottom of the eductor casing. Water will be discharged through the eductor casing. The sudden release of air is to be avoided. If the air supply is turned on too quickly, air will blow out the bottom of the eductor casing and water will be discharged between the well casing and the eductor casing.

Surging and backwashing are accomplished by shutting the air supply off when the water reaches the top of the eductor casing. The water column falls back into the well causing backwash of the screen, filter pack, and surrounding formation. Air lift pumping should be allowed to continue with periodic surging of the well until the well is sufficiently developed.

<u>Well Development Criteria</u>. A well is considered developed when the purged water is as clear and sediment free as the formation will allow and when the field supervisor determines that the discharge rate of the well is representative of the aquifer characteristics.

REFERENCES

F.G. Driscoll, *Groundwater and Wells*, 2nd edition, Johnson Division, 1986.

TECHNICAL MEMORANDUM

PREPARED BY: Richard Hicks

DATE: February 1990

TITLE: Commonly Used Surveying Techniques for Investigation Sites

PURPOSE

There are two objectives in conducting a survey of a subject site: 1) establishing monitoring well top-of-casing elevations to be used in determining groundwater level elevations and 2) precisely locating on-site structures and features for use in developing an accurate base map of the site. The guidelines provided herein are not meant to be used on complex sites where dramatic changes in elevation exist or where on-site features are very numerous or far apart. These procedures are, however, adequate for more typical investigation sites.

Well Top-of-Casing Survey

Well top-of-casing elevations are to be surveyed in using direct (or differential) leveling techniques. Leveling equipment includes a dumpy level or transit and a self-reading rod graduated into 0.01 foot increments such as a Philadelphia rod.

Benchmarks.

The leveling procedure follows a logical progression of addition and subtraction. First, an elevation benchmark (B.M.) is established as the origin of the survey. An elevation survey for most purposes can proceed from either an actual survey monument of known elevation (that was established by the U. S. Geodetic Survey, the State Department of Transportation or perhaps a city or county engineering department) or it can proceed from a benchmark established on site that is assigned an arbitrary elevation. Obviously, establishing on-site elevations that are relative to an actual elevation datum (mean sea level) is preferred and an effort should be made to locate a survey monument as the origin. However, establishing an on-site origin benchmark that can be tied-in to mean sea level at a later date is acceptable and preferable to spending days to traverse from and return to a distant survey monument.

The on-site origin benchmark should be established on a flat, immovable and easily recognizable surface, such as a curbing, manhole cover or property corner monument, that is not likely to ever be destroyed by future construction on the site. It should be clearly marked with spray paint and have its location and assigned elevation faithfully recorded in the survey notebook.

PROCEDURE

Once the benchmark has been established, the survey traverse, or progression from point to point, should be carefully thought out so that it can proceed smoothly and efficiently. Keep in mind that sightings cannot be taken through buildings or dense foliage and that the location of the survey instrument relative to the points that are being tied together is important for that reason. Also, long range sightings should be avoided, especially on hot days. The longer the shot - the greater the margin of error.

The basic leveling procedure that is to be repeated over and over includes the following steps (taken from the origin benchmark).

1) Set the survey instrument up by stabilizing the tripod, leveling the spirit level(s) on the instrument , rotating the instrument, first 90 degrees, then 180 degrees and finally 360 degrees (checking and adjusting the spirit level until it remains level over a 360 degree rotation). If it cannot be leveled, there is no need to proceed further.

2)Make a backsight to a rod placed on the origin benchmark. A backsight(B.S.) is a sight taken with the level to a point of known elevation. The backsight rod reading is added to the benchmark elevation to obtain the instrument height (H.I.).

3) The instrument is carefully rotated and the instrument man (person) beckons the rodman (-person) to the next station (Sta.), which could be benchmark or one of the well tops of casing. If the next station is to be another benchmark, it should be established on either a survey stake driven solidly into the ground or on a clearly-marked, smooth surface.

4) Make a *foresight* to a rod set on the new station. A foresight (F.S.) is a sight taken with the level to a point the elevation of which is to be determined. The foresight rod reading is subtracted from the instrument height to establish the new station elevation.

5) With the rodman remaining in place, the instrument man moves to the next instrument location, sets the tripod, levels the instrument, and takes another backsight. This station, be it a benchmark or well top of casing, is then referred to as a turning point. A turning point (T.P.) is fixed point or object used in leveling where the rod is held first for a foresight and then for a backsight. And so the survey proceeds...

Closing the Survey

An elevation survey is said to be closed when the rodman returns to the origin benchmark and a final foresight is taken. The objective of closure is to determine if any error was made by comparing the elevation of the origin with the final backsight reading. Under typical conditions, a difference of no greater than +/- 0.01 feet will be acceptable. If the closure error is greater than 0.01 feet, the instrument man's calculations should be checked for errors. If no math error accounts for the elevation difference, it is necessary to repeat the survey or the segment of the survey in which the error occurred. Since a bad survey is useless and must be repeated, a careful approach is worth the extra trouble.

Note Taking

The instrument man's notebook is the only record of the survey. Any future survey work at the site will depend entirely on these original notes and the accuracy of the original work. It is, therefore, obviously important that the notebook entry is recorded legibly and with enough detail that it can be interpreted by someone else in the future. A typical well elevation survey notebook entry is presented below.

Some Other Points and Hints

- Reading the rod. When viewing through the instrument, notice that there are three horizontal crosshairs. The darker, center horizontal crosshair is used in elevation surveying. A common error made by the instrument man is reading the wrong crosshair.

- Establishing the measuring point on a well. The measuring point on a well top of casing is always established on the north side. An indelible marker should be used to place an inverted "V" on the outside of the casing opposite the measuring point. No mark should be placed inside the casing. Also, do not make the mistake of establishing this elevation on the outer protective casing. The measuring point should be determined on the PVC well casing.

- Segmenting the survey. When the survey involves multiple elevation measurements over a long traverse distance, it is wise to break it up into independent segments that can be tied in to each other. If an error in measurement occurs in this case, the entire survey would not have to be repeated, only the segment in which the error occurred.

Reference

Davis, R. E., F. S. Foote and J. W. Kelly, 1966. *Surveying, Theory and Practice*, McGraw Hill, New York, 1096 p.

Precise Location of On-site Structures

The survey and construction of a detailed, to-scale site map is often better left to a licensed land surveyor. However, many small site maps can be accurately constructed from minimal data, especially if some form of to-scale plan already exists. The objective of this section is to describe a method for locating on-site structures and features (e.g., buildings, buried tanks, roads, streams, etc.) that can be used to make a better site map. The procedure employs basic transit-stadia, transit-tape or compass-tape traversing methods.

Transit-stadia Traversing

This method is the most accurate and probably the fastest if surveying equipment is available. The general procedure is to establish a point of origin, set up the instrument directly over the origin (using a surveyor's plumb level) and proceed to locate visible objects and features that are to be mapped by taking <u>azimuth</u> readings for direction and <u>stadia</u> readings for distance. The azimuth of a line (e.g., line of sighting) is its direction as given by the angle between the meridian (north-south) and the line measured in a clockwise direction, usually from the south branch of the meridian. The most common practice is to establish the azimuth north to be the line of the first sighting and subsequent readings are made relative to this first sighting. Stadia readings are obtained by employing the upper and lower horizontal crosshairs of the transit (or level). The incremental distance between these two crosshairs, as measured on the stadia rod, multiplied by 100 gives a close approximation of the distance (in feet) from the instrument to the rod.

When all visible objects or features are surveyed in from the origin, a traverse to another station becomes necessary. The next station is located following the same procedure as outlined above and the instrument is set up on the new station. A backsight is then taken to check the new station location. The same procedure is followed and the survey is ultimately closed back to the point of origin.

Transit-tape traversing

The transit-tape method is essentially the same as the procedure outlined above. The only variation is the use of a tape for measuring distance. This method is somewhat slower than the transit-stadia method but the tape can also be used to scale off distances that can be noted and not necessarily surveyed in (such as the back side of a building or a distance between tank fill ports) and the number of survey stations can be reduced.

Compass-tape traversing

The compass-tape method is the same as above except that magnetic compass bearings can be used instead of azimuth readings. If surveying equipment is not available, a compass and tape are adequate, especially for smaller sites.

Note taking

As in the case of the elevation survey, the surveyor's notebook is the only record of the survey. The direction and distance notes must be taken back to the office and, with the use of a ruler scale and protractor, reduced to a site map. Thus, good notes, including a sketch identifying all of the objects and stations surveyed in, must be taken. The survey error is never usually identified until the map is made. An example of a transit-stadia traverse entry is shown below.

Reference.

Davis, R. E., F. S. Foote and J. W. Kelly, 1966. *Surveying, Theory and Practice*, McGraw Hill, New York, 1096 pp.

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SOUTHERN DIVISION NAVAL FACILITIES
ENGINEERING COMMAND

SPECIFICATIONS FOR GROUNDWATER MONITORING WELL INSTALLATION

PART 1: GENERAL

1.1 INTRODUCTION

Groundwater monitoring wells shall be located at sites approved by the Southern Division Engineer-In-Charge (EIC) and the Activity Environmental Coordinator (EC). All applicable local, state, and federal regulations concerning well installations or soil borings will be followed.

1.2 APPLICABLE PUBLICATIONS

The publications below form a part of the specification to the extent referenced. The publications are referred to in this text by designation only. The latest revision of the specifications shall be followed.

1.2.1 American Association of State Highway and Transportation Officials (AASHTO)

M 220 Epoxy Coatings Specifications

1.2.2 American Society of Tasting and Materials (ASTM)

A 120 Pipe, Steel, Black and Hot-dipped, Zinc coated, welded, and seamless

A 312 Seamless and Welded Austenitic Stainless Steel Pipe

B 209 Aluminum and Aluminum-alloy Sheet and Plate

C 150 Portland Cement

C 778 Standard Sand

D 1457 Polytetrafluoroethylene (PTFE) Molding and Extrusion

D 1785 Standard Specification of Polyvinyl Chloride Pipe (PVC pipe, Schedules 40, 80, 120)

D 1586 Method for Penetration Test and Split Barrel Sampling of Soils

D 1587 Practice for Thin Wall Tube Sampling of Soils

D 2113 Diamond Core Drilling for Site Investigation

F 480 Thermoplastic Water Well Casing, Pipe and Couplings made in Standard Dimension Ratios (SDR)

F 883 Padlock

1.2.3 American Petroleum Institute (API)

13-A Oil Well Drilling Fluid Specifications

1.3 SUBMITTALS

1.3.1 A completed "Southern Division Naval Facilities Engineering Command Groundwater Monitoring Well Installation Report" will be submitted for each well installation.

1.3.2 Certificates of Conformance

a) Casing
b) Screen
c) Grout
d) Drilling Mud
e) Gravel Pack
f) Caps and Plugs
g) Centralizers
h) Surface Casing
i) Well Protective Cover
j) Flush Mount Protective Cover
k) Padlock
l) Protective Post
m) Well Designation Sign
o) Epoxy Paint

1.4 DELIVERY AND STORAGE

All materials shall be delivered in undamaged condition, stored off the ground, and protected from the weather in an area designated by the EC. All defective or damaged material will be replaced with new material.

PART 2. PRODUCTS

2.1 All materials shall conform to the respective specifications and other requirements as specified herein.

2.1.1 Well Casing (threads compatible with well screen below)

Material type will be approved by the EIC. The material provided will have adequate strength to resist external forces both during and after installation. Markings, writing, or paint strips are not allowable on any of the materials.

a. PVC, flush threaded joints (schedule 40) ASTM F480 and ASTM D1785

All PVC flush threaded joints will meet or exceed the water pressure ratings (at 73 degrees Fahrenheit) for the size and schedule of PVC pipe used in the project, as listed in ASTM D1758: Table XI.2.

b. Polytetrafluoroethylene (PTEF), flush threaded joints, slotted, ASTM D1457

Virgin materials shall be used to meet the ASTM specification. Certification of compliance and joint evaluation are required. Shall be shipped in closed containers. PTFE "O" rings will be used to seal all joints.

c. 316 stainless steel, flush threaded joints, ASTM A312
d. 304 stainless steel, flush threaded joints, ASTM A312

End fittings shall be double entry flush screw threads. The casing shall be cleaned in the following manner: 5-minute immersion in static bath of acid, pressure wash with detergent and cool water, rinse with warm water, and allow to air dry.

2.1.2 Well Screen

Material type will be approved by the EIC. The material provided will have adequate strength to resist external forces both during and after installation. Water velocity through the screen openings shall not exceed 0.1 foot per second. The opening size will be determined from an analysis of the material in geologic formation to be screened and/or the size of the filter pack material. Markings, writing, or paint strips are not allowable on any of the materials.

a. PVC, flush threaded joints (schedule 40), slotted, ASTM F480 and ASTM D1785

Two inch I.D. screens will have three rows of slots with a spacing of 1/8 inch between slots. Four-inch I.D. screens will have six rows of slots with a spacing of 1/8 inch between slots. All PVC flush threaded joints will meet or exceed the water pressure ratings (at 73 degrees Fahrenheit) for the size and schedule of PVC pipes as listed in ASTM D1785, Table XI.2.

b. polytetrafluoroethylene (PTFE), flush threaded joints, slotted, ASTM D1457

Virgin materials shall be used to meet the ASTM specification. Certification of compliance and joint evaluation are required. Shall be shipped in closed containers. PTFE "O" rings will be used to seal all joints.

c. 316 stainless steel, wire wrapped, flush threaded joints, ASTM A312
d. 304 stainless steel, wired wrapped, flush threaded joints, ASTM A312

The screen shall be continuous slot, wire wound design. It shall be fabricated by circumferentially wrapping a triangularly shaped wire around a circular array of internal rods. The configuration must produce sharp outer edges, widening inward. PTFE "O" rings will be used to seal all joints. End fittings will be welded to the screen body.

2.1.3 End Plugs, flush threaded joints compatible with casing and screen above)

The end plug shall match the type of material selected for the screen or casing above. All ASTM specifications that apply to the above materials shall apply to the end plugs. Markings, writing, or paint strips are not allowable on any of the above materials.

2.1.4 Well Caps, flush threaded joints (Compatible with casing above)

The well cap shall match the type of material selected for the casing above. All ASTM specifications that apply to the above materials shall apply to the well caps. Markings, writer, or paint strips are not allowable on any of the above materials.

2.1.5 Adjustable centralizers

The centralizer shall be capable of keeping casing and screen straight and plumb in the borehole during well installation. The material type shall be compatible with above casing and screen. No solvents or glues will be used.

2.1.6 Annular space fill materials

a. Filter pack (98% pure silica, cleaned with potable water, uniformity coefficient of 1-3, specific gravity 2.6 - 2.7). Shall meet ASTM C 775 standard sand specifications.

b. 1/4-inch bentonite pellets (90% montmorillonite clay, bulk dry density 80 lbs/cu ft., specific gravity 1.2, pH of 8.5-10.5)

c. Granular bentonite (API std 13-A for bentonite)

d. Portland Cement (ASTM C 150 Type I)

2.1.7 Surface casing (steel) ASTM A 120

a. 24-inch diameter 0.25-inch wall thickness
b. 20-inch diameter 0.25-inch wall thickness
c. 16-inch diameter 0.25-inch wall thickness
d. 10.75-inch diameter 0.25-inch wall thickness
e. 24-inch diameter 0.50-inch wall thickness
f. 20-inch diameter 0.50-inch wall thickness
g. 16-inch diameter 0.50-inch wall thickness
h. 10.75-inch diameter 0.365-inch wall thickness

2.1.8 Surface Completion

a. Locking 16-gauge steel protective well cover, round or square and 5-ft. in length

b. Flush mount 22-gauge steel, water resistant welded box with 3.8-inch steel lid, locking device, and padlock guard

c. Concrete pad at ground surface (3' x 4' x 6")

d. Padlock (brass, corrosion resistant, keyed alike)

e. Steel protective post (4-inch diameter, 6-ft. length, 1/4-inch thickness, concrete filled) ASTM A 120.

f. Well designation sign, sheet aluminum, ASTM B 209, 1.8 inch by 18 inch by 6 inch, anchors and fasteners compatible with sign, designation to be provided by EIC pressure sensitive precision cut 4-inch vinyl letters, fastened to well cover.

g. High visibility yellow epoxy paint

PART 3: EXECUTION

3.1 DRILLING METHOD

The proposed drilling method must be approved by the EIC. Hollow-stem auger methods will be given first preference, rotary methods second, and any other methods normally require detailed evaluation.

3.2 WELL INSTALLATION

Well depths, length of screen and sump will be determined on a site-specific basis with approval of the EIC. Screen lengths will be limited to 10 feet unless specifically approved in writing by the EIC. Two-inch well diameters will be specified for shallow well installations. Deeper installations or anticipated conversion to recovery wells may require 4-inch wells. Recovery well specifications will be approved by the EIC.

Well installation shall follow commonly accepted professional drilling procedures. The borehole will be logged as drilling proceeds by a qualified geologist/hydrogeologist (shall meet minimum qualifications for Geologist-in-Training as described in Article 1, Chapter 23, Title 1, Code of Laws of South Carolina: Rules of the South Carolina State Board of Registration for Geologists). Soil samples shall be collected according to one of the following methods: ASTM D 1586-Method for Penetration Test and Split Barrel Sampling of Soils or ASTM D 1587-Practice for Thin Wall Tube Sampling of Soils. Consolidated Rock will be sampled according to ASTM D2113 Diamond Core Drilling for Site Investigation. Gravel pack, seals, and grout will be installed using tremie methods. Bentonite seals shall be allowed to hydrate the time period specified by the manufacturer. Measurements to the top of the gravel pack and seals shall be made accurately with a weighted steel tape and adjusted to reflect the top of casing. If water is used in the drilling process, a sample shall be collected from the source and analyzed for the parameter specified in the investigation.

3.3 WELL DEVELOPMENT

Well development shall take place no sooner than 24 hours after placement of the grout. The development method shall be approved by the EIC. The selected method shall be capable of removing all drilling fluids and cuttings from inside the well, within the gravel pack, and within the formation. The method shall prevent the introduction of any type of contamination into the aquifer from the development process. Introduction of outside water to the well shall be minimized. Any water introduced into the well shall be recovered to the maximum extent possible. A written report will be required describing why any introduced water could not be recovered.

The development process should result in wells that are sediment free. A well that produces turbid water (as defined by the Safe Drinking Water Act PL 93-523) may be rejected by the EIC.

3.4 MATERIAL DISPOSAL

All borehole cuttings and development water will be contained in DOT 17-C Open-top 55-gallon drums, permanently labeled by well number and stored in a location designated by the EC. The requirement may be waived if approval is given in writing by the EIC. The Navy will be responsible for disposal.

3.5 DECONTAMINATION

All down hole drilling equipment, the drill rig, tools, etc., will be decontaminated according to the approved Quality Control Plan prior to beginning work, between each well location, and after the last well is completed. The drill rig will be placed on 10-mil polyethylene sheeting at each drilling site to prevent any spillage or leaking of hydraulic fluid or fuel from reaching the ground surface. All of the decontamination waste will be handled according to section 3.4 above.

3.6 WELL PROTECTION

A steel, hinged, locking protective casing will be installed within a 3-ft. by 4-ft by 6-inch thick concrete pad. The pad will be set level and 4-inch below grade. The pad shall be installed so that surface runoff does not pond around the well casing and protective cover. If designated by the EIC, four steel protective post will be installed at the four corners of the pad but not set within the pad. The post will be 6-ft in length, 4-inch in diameter and have a wall thickness of 0.25-inch. The post will be filled with concrete and set three feet below grade in a 10-inch diameter hole with concrete backfill. The protective casing and any protective post installed shall be painted with two coats of high visibility yellow epoxy paint that meets the specifications of AASHTO M 200. The protective casing will be locked with a Type P01 (Key Operated), Option E (Corrosion Resistant) padlock that conforms to ASTM F 883. If more than one padlock is required, the padlocks shall be keyed alike. Two keys, for the locks installed, shall be delivered to the EIC and two to the EC.

3.7 WELL DESIGNATION

A permanent sign will be attached to the protective casing. The well designation number will be taken from the attached list of "IRP Well Numbering System".

4.0 INSTALLATION RESTORATION PROGRAM WELL NUMBERING SYSTEM

The system will locate a particular well on an activity, key it consistent with the Initial Assessment Study (IAS) of the Activity, and sequentially number them at each site. The EIC will provide designations for sites not included in the IAS.

Example:	CEF-1-1	Cecil Field, Site 1, Well 1
	KYW-5-8	Key West, Site 5, Well Number 8

FLORIDA

Cecil Field	CEF
Ft. Lauderdale	FLD
Key West	KYW
NavHosp Key West	KWH
Homestead	HST
Jacksonville	JAX
Mayport	MPT
Panama City	PCY
Whiting Field	WHF
Andros Island	AIS
Pensacola	PEN
Saufley	SFY
Correy Station	CRY
Orlando	OLD

GEORGIA

Albany	ALB
Atlanta	ATL
Kings Bay	KBA
Athens	ATH

SOUTH CAROLINA

Parris Island	PAI
Beaufort	BFT
NavHosp Beaufort	BFH
NWS Charleston	NWS
NS Charleston	CSY

LOUISIANA

NAS New Orleans	NOS
NSA New Orleans	NOS

MISSISSIPPI

Gulfport	GPT
NavHome Gulfport	GPH
Meridian	MRD

TENNESSEE

Memphis	MPH
Bristol	BRT

TEXAS

Corpus Christi	CCT
Chase Field	CAF
Kingsville	KVE
NAS Dallas	DNA
NWIRP Dallas	DWP
McGregor	MGR

STANDARD SPECIFICATIONS
FOR
SUBSURFACE BORING AND SAMPLING

GENERAL CONDITIONS

Article 1. **EMPLOYEES AND HOURS OF LABOR**

a. DRILLING SUBCONTRACTOR shall at all times enforce strict discipline and good order among his employees, and shall not employ on the work any person not skilled in the work assigned to him or otherwise unfit to perform his duties. Whenever CONTRACTOR shall notify DRILLING SUBCONTRACTOR, in writing, that any man on the work is, in his opinion, incompetent, unfaithful, disorderly or otherwise unsatisfactory, such a man shall be discharged from the work and shall not again be employed on it, except with the consent of CONTRACTOR.

b. The actual making of subsurface boring shall be done during the usual eight (8) hour day shift or during hours which are prearranged and suitable to both CONTRACTOR and DRILLING SUBCONTRACTOR. DRILLING SUBCONTRACTOR may, at his option, pull casing and change locations of his rigs at other hours of the day, if CONTRACTOR is notified previously.

Article 2. **BORING FOREMAN**

a. DRILLING SUBCONTRACTOR shall keep at the site of the work, during its progress, a competent boring foreman and any necessary assistants, all satisfactory to CONTRACTOR. The boring foreman shall not be changed except with the consent of CONTRACTOR, unless the boring foreman proves to be unsatisfactory to DRILLING SUBCONTRACTOR and ceases to be in his employ. The boring foreman shall represent DRILLING SUBCONTRACTOR in his absence and all directions given to him shall be as binding as if given to DRILLING SUBCONTRACTOR himself. Verbal directions shall be confirmed in writing on request in any case.

b. DRILLING SUBCONTRACTOR shall give personal supervision to the work, using his best skill and attention.

Article 3. **INSPECTION OF WORK**

CONTRACTOR and their representatives shall at all times have access to the work, and DRILLING SUBCONTRACTOR shall provide proper facilities for such access and for inspection. The making of borings, the taking of samples, the recording of samples and the storing and disposal of samples, shall be in accordance with the requirements of these specifications and the directions of CONTRACTOR and will be inspected by a representative of CONTRACTOR at his discretion. The storing and disposal of samples will be CONTRACTOR's responsibility.

Article 4. PERMIT AND REGULATIONS

Permits and licenses necessary for the prosecution of DRILLING SUBCONTRACTOR's work shall be secured and paid for by DRILLING SUBCONTRACTOR. DRILLING SUBCONTRACTOR shall give all notices and comply with all laws, ordinances, rules and regulations bearing on the conduct of the work as drawn and specified.

Article 5. PROTECTION OF WORK, PUBLIC AND PROPERTY

DRILLING SUBCONTRACTOR shall continuously protect his work from damage, and protect adjacent property as provided by law. He shall maintain lights and other safety devices as required by public authority or local conditions. He shall promptly repair all damages caused by his operations under this Agreement. Internal combustion engines if used inside buildings or enclosed areas, shall have their exhaust piped to the outside of the building or enclosed area. In such cases at each location and at all times of use of internal combustion equipment, DRILLING SUBCONTRACTOR shall provide emergency fire extinguishers or other approved fire fighting apparatus.

DRILLING SUBCONTRACTOR may occupy during his operations only those portions of streets and public places at the boring locations for which the required permits have been obtained by him. If DRILLING SUBCONTRACTOR desires to use additional areas outside of those required for the borings, he shall arrange for such areas at his own expense.

DRILLING SUBCONTRACTOR shall take every precaution against injuring paving, utilities, or private properties and shall promptly repair at his own expense any damage to such paving, utilities, or private property to the satisfaction of CONTRACTOR. This requirement includes the filling of all drill holes and the resodding of any areas where the grass is damaged. Any abutting property which is damaged as the result of DRILLING SUBCONTRACTOR's operations shall be repaired at DRILLING SUBCONTRACTOR's expense to the satisfaction of CONTRACTOR.

The location of all stationary and mobile equipment shall be subject to the approval of CONTRACTOR, and upon the completion of DRILLING SUBCONTRACTOR's operations at each site, DRILLING SUBCONTRACTOR shall remove his equipment therefrom, shall clear the area of all debris and restore the area to the condition existing before the start of his operations. All casings shall be withdrawn from the drill holes unless ordered to be left in place by CONTRACTOR.

DRILLING SUBCONTRACTOR shall carry on his operations without interference or delay to traffic. DRILLING SUBCONTRACTOR shall furnish all labor, materials, watchmen, barricades, signs, lights, and any additional expenditures necessary to maintain traffic and to protect his work and the public during the operations, at no additional cost. The cost of this work shall be included in the various bid prices named in the Agreement.

Article 6. STORAGE

DRILLING SUBCONTRACTOR shall provide suitable space on the site for the storage of boring equipment unless such space is specifically made available by CONTRACTOR. Undisturbed and "Shelby" tube samples should be protected from extreme heat and from freezing at all times.

Article 7. DELIVERY OF SOIL SAMPLES

DRILLING SUBCONTRACTOR shall deliver all soil samples to CONTRACTOR's Field Representative at the conclusion of each working day or as specified by CONTRACTOR. The soil sample container shall be identified with a label to indicate the location and depth of the sample.

CONDITIONS AND WORKMANSHIP

Article 8. Drawings

a. Figure 1-1. Location of monitoring wells

Further drawings and instructions will be furnished as necessary.

Article 9. NUMBER AND LOCATIONS OF BORINGS

a. The number and exact locations of borings will be designated by CONTRACTOR.

b. Figure 1-1 shows the approximate areas where borings will be made.

c. Monitoring wells will be installed at the general locations shown on Figure 1-1 and as designated by CONTRACTOR.

d. DRILLING SUBCONTRACTOR will be paid only for the borings and monitoring wells completed and accepted at the unit prices stated in the Agreement, during the period stated.

e. CONTRACTOR makes no representations as to the character of the subsoil through which the borings are to be advanced, or that any boring location given will be found free from obstructions.

Article 10. ABANDONMENT AND COMPLETION OF BORINGS

a. Borings shall not be abandoned before reaching the final depth ordered by CONTRACTOR except on the approval of CONTRACTOR. No payment will be made for borings abandoned by reason of an accident or negligence attributable to DRILLING SUBCONTRACTOR.

   Borings abandoned before reaching required depth, due to an obstruction or other reasonable cause not permitting completion of the boring by standard procedures, shall be replaced by a supplementary boring adjacent to the original and carried to the required depth. Penetration to the completed depth of the original boring may be made by means other than specified in Attachment A only upon approval of CONTRACTOR. Samples shall be taken in the supplementary boring from the elevation at which the original boring was abandoned in a manner specified for the original boring. Abandoned borings shall be filled in accordance to procedures described in Article 10, Section B.

If abandoned for reasons acceptable to CONTRACTOR, payment will be made for the approved portion of the abandoned hole plus that portion of the supplementary boring extending below the final elevation of the original boring, provided DRILLING SUBCONTRACTOR presents soil samples and records as specified plus a report on the obstruction which necessitated relocating the boring.

b. Upon completion, all borings in which monitoring wells are to be installed, shall be backfilled as shown in Figure 2-1. Clean silica sand will be required around the well screen area. Native soils may be used above as backfill above the bentonite pellet seal. Clean sand or a bentonite cement slurry may be required around any portion of the well riser not filled with native soil material. A 2-foot minimum bentonite pellet seal will be required at the beginning of any backfilling process using bentonite pellets. Any other material used for backfill around the well riser must be approved by CONTRACTOR.

   Borings in which monitoring wells are not installed will be completely backfilled with a grout mixture of 90 percent by weight Portland Cement and 10 percent by weight quick gel bentonite. The grout will be injected into the bottom of the borehole as the casing is withdrawn. The grout mixture shall extend continuously the full depth of the borehole to the ground surface.

Article 11. SAFETY

CONTRACTOR's Safety Plan will be observed for all work performed under this Agreement. The Safety Plan, which will be provided to DRILLING SUBCONTRACTOR, is briefly summarized below:

Requirements of the Occupational Safety and Health Act (OSHA) 29 CFR provide the basic safety requirements for this PROJECT. Special safety requirements are in addition to OSHA regulations. CONTRACTOR may require procedures in addition to those required by OSHA. The responsibility for the implementation of this Safety Plan lies with DRILLING SUBCONTRACTOR.

Article 12. DISPOSAL OF CUTTINGS AND DRILL FLUIDS

Water and drill cuttings generated during completion of the borings and development of monitoring wells shall generally be disposed of at the drilling site in a manner to be ordered by CONTRACTOR. At no time shall drill cuttings, drill water or well development water be discharged directly into existing natural bodies of water. If determined necessary by CONTRACTOR drill cuttings and or water shall be appropriately contained at the site. The party responsible for these materials will be clearly identified before the beginning of on-site activities.

EQUIPMENT, MATERIALS, TOOLS, CONTAINERS, ETC.

Article 13. DRILL RIGS AND TOOLS

Drill rigs shall have adequate capacity and power. They shall be specifically designed and manufactured for drilling, coring, and sampling soils and rock. Drill rigs and tools that are not adequate, in the opinion of CONTRACTOR, will not be permitted.

Article 14. HOLLOW STEM AUGERS

a. DRILLING SUBCONTRACTOR shall provide hollow stem augers in quantities and sizes adequate for expeditious performance of the work. Hollow stem augers used for completion of borings in which monitoring wells will be installed must be at least 6-inches in inside diameter (I.D.). Casing must be of sufficient diameter to allow a minimum 8-inch boring in which to install any monitoring wells. Larger sizes may be required where obstructions or difficult penetration requires special procedures. Any special procedure used must be approved by CONTRACTOR.

b. All borings are to be cased in full depth as required to adequately maintain the borehole and permit any required monitoring well to be properly installed. In borings into bedrock, the casing shall extend the full depth of the overburden and as far into bedrock as required to adequately maintain the bedrock and permit any required monitoring well or piezometers to be properly installed.

Article 15. SOIL SAMPLING DEVICES

Soil sampling devices shall be approved by CONTRACTOR before their use, but shall generally be described as:

a. Split Spoon Sampler: Sampler shall be of the split barrel, ball check design, inside minimum length of 30 inches and outside diameter of 2 inches. Flap valve or spring type retainers are allowed only with special permission of CONTRACTOR. For material requiring more than 30 blows per foot, a 12-inch split barrel will be acceptable. The beveled edge of the drive shoe shall be maintained in good condition and, if excessively work, shall be reshaped to the satisfaction of CONTRACTOR. The drive shoe of the sampler shall be replaced, if damaged in such a manner as to cause projections within the interior surface of the shoe.

b. Sample Jars: Glass, wide-mouthed jars of one-pint capacity with airtight screw covers are required. Jars are to be placed in wooden boxes, metal containers or cardboard partitioned for twelve (12) jars (3 by 4 array).

   Cardboard shall be corrugated kraft paper board sufficient in strength to safely contain twelve (12) jars full of soil samples.

c. Boulder and Rock Core Boxes: Boxes shall be 60 inches long by 11-1/8 inches wide by 3-3/4 inches deep for N size cores. Core rows shall be separated by wooden or tempered hardboard strips not less than 1/8-inch thick, recessed 3/8-inch into the bottom and ends of the box. Covers shall be hinged with two steel butt hinges and arranged to be secured closed with two hooks and eyes. Alternative core boxes may be employed if approved by CONTRACTOR.

SAMPLING PROCEDURES

Article 16. DRY SAMPLE BORINGS

Auger borings are to be advanced using hollow stem augers not less than 6-inches inside diameter for monitoring wells. At every change in soil formation, in intervals not to exceed 5 feet, hole advancement shall be stopped, and an ordinary dry sample of the material shall be taken. Additional samples may be taken as ordered by CONTRACTOR where soil conditions show significant stratification. These samples shall be taken by sampling barrels described in Article 15. The samples shall be removed from the hole in unwashed conditions in such a manner as to provide a true sample of the soil formation from which they are recovered.

Cased borings are to be advanced using ordinary boring techniques by driving casings not less than 6.0 inches in diameter and removing the soil from within the casings by washing. Cleaning out the hole where casing is used shall not be done by washing through a sampling spoon or open-end drill rod unless prior approval is obtained from CONTRACTOR. Washing shall be done by using either air or water. The use of rotary drilling techniques with weighted drilling mud, or other methods to advance and maintain a stabilized hole will not be permitted unless prior approval is obtained from CONTRACTOR. Casings shall be driven down without washing in stages of not more than 5 feet, after which the material shall be cleaned out to the depth of the casing. Unless otherwise approved by CONTRACTOR, casing shall be driven by a free-falling drop hammer weighing 300 pounds and falling 16 inches. At every change in soil formation, or in intervals not to exceed 5 feet, hole advancement shall be stopped, the loose material shall be removed from the hole, and an ordinary dry sample of the material shall be taken. These samples shall be taken by sampling barrels described in Article 15. The samples shall be removed from the hole in unwashed conditions in such a manner as to provide a true sample of the soil formation from which they are recovered.

Requirements for the soil sampling with a split spoon sampler are as follows:

a. All samples shall be obtained by driving the split barrel sampler in undisturbed ground beneath the bottom of the casing. Samples shall be recovered at every change in soil formation and at vertical intervals not to exceed 5 feet or continuously, except as noted above.

b. Particular care shall be taken to remove all soil to the bottom of the casing before sampling.

c. The split spoon sampling barrel shall be driven by a free-falling drop weight weighing 140 pounds and falling 30 inches. The sampler shall be driven using Standard A-rods connected between the sampler and drive head unless use of other equipment is approved by CONTRACTOR.

d. In all soils requiring less than 30 blows per foot of penetration, the sampling barrel shall be driven 18 inches with the number of blows for each 6 inches of penetration observed and recorded.

e. In soils requiring 30 or more blows per foot of penetration, the sampling barrel shall be driven 12 inches, with the number of blows for each successive 6 inches of penetration observed and recorded. In extremely hard materials requiring over 80 blows per foot, the blows for smaller amounts of penetration may be observed and recorded with special note of the amount of penetration actually obtained.

f. Trap doors or flap valves protruding at any point into the inside diameter of the sampler may not be used without prior approval of CONTRACTOR. If less than 6 inches is recovered on one sampling attempt, DRILLING SUBCONTRACTOR shall drive casing to bottom level of the missed sample, clean out and repeat the sample attempt. If recovery is less than 6 inches in the second sample, a sampler equipped with a basket shoe or other spring type retainer shall be used.

g. Immediately on removal from the hole, the split barrel sample shall be tightly sealed in screw-cap, wide-mouth pint glass jars or bottles. The jars shall be provided with airtight metal screw caps. Each sample container shall be labelled to show plainly the number of the hole, the date, the depth from which the sample was taken, and the number of blows for penetration of the sampler as previously specified. Samples shall be placed in the jars in the condition in which they are removed from the split barrel sampler without squeezing, mashing or otherwise excessively distorting the sample. If more than one type of soil is retrieved in a spoon sample, a specimen of each type of soil shall be placed in separate sample containers, with depths or changes noted and described as required. DRILLING SUBCONTRACTOR shall, at his expense, provide such containers, keeping a sufficient supply on hand to prevent any delay in the work.

h. When cohesive soils are encountered, DRILLING SUBCONTRACTOR is required to take samples in a 3-inch O.D. open-type "Shelby" tube sampler unless split spoon sampling is authorized by CONTRACTOR or is stated in Section A. The sample tubes shall be 30 inches long and be provided with a positive ball check valve in its head. Such samples shall be obtained by pushing, jacking, or pressing the sampler into undistributed soil at the bottom of the hole. Wherever possible, the equipment for advancing the sampler shall measure the force required to penetrate the soil. DRILLING SUBCONTRACTOR shall record this force, the time required for penetration, depth of penetration and length of sample recovered. These samples shall be sealed in the tubes which they are obtained and carefully labelled to show location and depth of sample.

Article 17. <u>CONTINUOUS SAMPLING</u>

Continuous sampling in certain borings or through certain soil strata may be called for in particular borings, or many be requested by CONTRACTOR on the basis of information disclosed by the borings. Continuous sampling is anticipated in half of the borings. Continuous sampling shall mean the securing of successive samples in thin-walled sampling devices or a split spoon sampler.

Continuous sampling in cohesionless silts, sands, and gravels, and in strata where cohesive soils are interlayered with non-cohesive materials shall be taken with 2-inch split spoon sampler with a tube length of at least 24 inches. This sampler shall be operated as specified in Article 16. Continuous sampling in cohesionless soils shall be performed when ordered at the unit prices stated in the Contract for the applicable size and type of boring sample.

When continuous sampling is required in cohesive soils, samples shall be taken in an open-type "Shelby" tube sampler and cleaning of the hole between samples shall be accomplished as specified when ordered at the unit prices stated in the Contract for the applicable size and type of boring and samples.

Measurements of all materials recovered in each such sample, including the percent of recovery, will be made and incorporated into the boring records. Materials recovered in this sampling operation shall be preserved in the same manner described in Article 16.

Article 18. <u>CORE DRILLING IN ROCK</u>

At times CONTRACTOR may require that core be recovered from specific depths within the bedrock mass. Selection of the means used to advance the boring between cored intervals is the responsibility of DRILLING SUBCONTRACTOR and must be approved by CONTRACTOR. If monitoring wells or piezometers are to be installed in the boring, below the bedrock surface, the bit or tool employed to advance the boring shall be of sufficient diameter to permit proper and expeditious installation of such instruments.

The individual drill runs in the coring operations shall in no case be in excess of 10 feet and shall be of such length, depending on the nature of the rock encountered, as to assure maximum core recovery. Every effort shall be made by DRILLING SUBCONTRACTOR to obtain maximum possible core recovery from the designated intervals. The core barrel and bit shall be in good condition. The rate of rotation and downward pressure of the core barrel and the pressure of circulating fluid shall be controllable and adjustable in a manner that will produce optimum core recovery. Drill rods shall be straight and drilling equipment used shall be of a type that will maintain continuous contract between the core bit and the rock being drilled. All significant actions of the bit and reasons for loss of core shall be recorded in the boring log.

DRILLING SUBCONTRACTOR shall preserve and deliver to CONTRACTOR, as specified in Article 7, the rock core obtained, stating the length of the core recovered compared with the actual depth of drilling required to obtain the sample. Each core shall be packed in a box, as specified in Article 15, in the order in which it is recovered from the hole. Core boxes shall be marked on the inside and the outside with the number of the borehole and depths from which the cores were recovered so that they may be easily identified. Wooden blocks shall be fastened in the box to separate the core runs and shall be marked to identify the core depth. When the core recovered is fragmented, all pieces of size less than the core diameter shall be put in plastic bags and placed in the approximate position in the core box.

Article 19. GROUNDWATER OBSERVATIONS, PIEZOMETER, MONITORING WELL INSTALLATION AND PACKER TESTING

a. Observations and recording of water levels during and at the completion of the drilling operations on a site shall be made according to the following guidelines:

   1. Date, time and depth from the ground surface to the water or dry soil surface (note depth to bottom of casing or bottom of hole, if uncased) measured and recorded at the beginning and completion of each day's work while a hole is being drilled.

   2. Notes pertaining to any noticeable loss or rise of the drill water during the advancing of a hole, to include date, time and depth to which the water dropped in the hole or height to which it rose in the casing. (If possible, extend casing above the ground high enough to prevent overflowing and to stabilize the water level overnight and after the completion of the hole).

   3. Date, time and depth to the water or dry soil surface (not depth to bottom of casing or bottom of hole, if uncased) at the completion of each borehole, both immediately before removing the casing and before leaving the hole location after the casing has been removed.

   4. Date, time and depth to the water or dry soil surface in all of the completed holes measured and recorded at least once daily after the completion and during the period the crew is still at the site, until a stabilized level is reached.

   5. Date, time and depth to the water or dry soil surface in all of the boreholes at the completion of the drilling on each site.

6. Notes regarding weather: rain, snow, clear; temperature (estimate to nearest 10°F)

7. Notes regarding surface water conditions and influence on water in boreholes.

8. Notes regarding surface water conditions and influence on water in borehole.

9 Records must be specific - Example: If hole is dry, record "Dry at depth of X Feet."

Observations of groundwater levels as specified above are considered the responsibility of DRILLING SUBCONTRACTOR and all costs therefore shall be included in the unit prices stated in the Contract for the various items of the work.

b. If required, DRILLING SUBCONTRACTOR shall install standpipe piezometers in certain boreholes designated by CONTRACTOR. The piezometer tip shall consist of a 3/4-inch diameter slotted PVC with 0.01 inch openings. The bottom of the tip shall be provided with a screw on cap. The riser shall consists of a 3/4-inch flush, jointed, threaded PVC pipe. No glue or solvents shall be used in constructing the piezometers.

Elevations for the proposed piezometers will be provided by CONTRACTOR. After the boring is completed, the hole shall be thoroughly cleaned, if necessary, by flushing with potable water and backfilled to the piezometer elevation. The piezometer shall then be placed in the casing with plastic pipe sufficient to reach 3 feet above ground surface. It is not anticipated that the native soil conditions will allow for a natural backfill due to collapse of the soil formation. Therefore, the space surrounding the piezometer should be backfilled with clean silica sand, well-graded between the No. 200 sieve and the No. 4 US standard sieve to a minimum of 2 feet above the well screen of the piezometer or as directed by CONTRACTOR and tamped while being placed. During all the backfilling operations, the casing shall be withdrawn in small increments so as to avoid disturbing the backfill, but without exposing the sides of the hole above the backfill at any time. A 6-foot length of 4-inch diameter or larger steel pipe or casing shall be placed in the borehole around the well riser pipe seated in the ground with Portland cement grout and capped. Alternative dimensions for protective casing must be approved by CONTRACTOR. The protective casing shall extend at least 2 inches and no more than 4 inches above the PVC riser. The location and number of the piezometer will be prominently and permanently marked on the casing. The protective casing shall be provided with a locking cap. DRILLING SUBCONTRACTOR will not be responsible for observations of water levels in the standpipe piezometer. All backfill placed in the boring will be approved by CONTRACTOR prior to use.

c. Monitoring well installations shall be completed in a manner similar to piezometer installations. A monitoring well shall consist of a 5-foot, 10-foot, 15-foot, or 20-foot (as required by CONTRACTOR) slotted screen 2 or 4 inches in diameter constructed of Schedule 40 or 80 PVC pipe or stainless steel, with openings 0.010 to 0.020 inches wide and sufficient 2- or 4-inch diameter, thread flush coupled Schedule 40 or 80 PVC or stainless steel pipe to reach 3 feet above the ground surface or flush with the ground surface if ordered by CONTRACTOR. Monitoring wells shall be placed in protective steel casings at least 4 inches in diameter (or larger) or in steel manholes with subsurface vaults.

The hole will be prepared, backfilled to the well elevation with collapsed soil material, sand and/or bentonite at the direction of CONTRACTOR and the well inserted. The casing will be withdrawn as the native soil material collapses around the well screen. At no time shall the borehole be unsupported by either the casing of backfill. The depths to the top of the sand backfill lifts and/or bentonite seals shall be measured by DRILLING SUBCONTRACTOR and recorded. Grouting shall be accomplished as specified for piezometers.

All monitoring wells shall have a surface protective casing constructed and labeled as specified for piezometers.

d. Monitoring wells and piezometers shall be developed by surge block, submersible pump, centrifugal pump or airlift methods until the well produces sediment-free water when pumped. The well will not be accepted by CONTRACTOR until it has been properly developed. DRILLING SUBCONTRACTOR may elect to employ alternative means of well development. Such alternatives may be used only after approval of CONTRACTOR.

e. Packer testing shall be interpreted to mean the operation of forcing water under pressure into subsurface rock formations through predrilled test holes of a size as called for by CONTRACTOR for the purpose of determining the permeability of the subsurface and/or grouting requirements. DRILLING SUBCONTRACTOR shall perform all the work and furnish all equipment and supplies required to complete these operations.

Packer testing equipment to be furnished by DRILLING SUBCONTRACTOR shall include the following: water pumps with minimum capacities of 35 gpm when operating at discharge pressures of 100 psi; double expander packers to fit the size hole drill with rubber expansion elements 6 inches in length set 5 feet apart; water pipes so arranged that water may be admitted either below the bottom expander element or between the two expanders, and connected to the pressure pump through two swing check valves, water meter, and pressure gauge. Supplies shall include all necessary valves, gauges, stopcocks, plugs, two sets of expanders, a supply of potable water for testing, standby pumps, fuel, pipes, pressure hose, and tools necessary for maintaining uninterrupted tests for each boring or portion thereof to be tested. Prior to testing a boring, DRILLING SUBCONTRACTOR shall test the apparatus on the ground surface by inserting and sealing it into a section of casing. A pressure of 100 psi should then be maintained for five (5) minutes with no indication of leakage. DRILLING SUBCONTRACTOR should exercise caution when lowering the apparatus into position so that the rubber packers are not damaged.

All pressure tests shall be made in the order and manner directed by CONTRACTOR and as presented in *The Foundation Engineering Handbook*, Winterkorn and Fang, 1975, Section 1.10. DRILLING SUBCONTRACTOR shall pressure test each hole in 5-foot sections, commencing at the bottom of the boring and progressing upward to the top of rock. For each lift, the maximum water pressure employed shall be directed by CONTRACTOR, but in no case shall the pressure exceed 100 lbs per square inch. DRILLING SUBCONTRACTOR shall develop the maximum pressure specified by CONTRACTOR in accordance with the above statements, and, maintaining this pressure constant for a minimum period of five (5) minutes, record the total volume of flow in gallons or cubic feet over this time interval. After completion of the above flow test, the pressure pump and flow into the boring shall be simultaneously cut off, and the time noted for each drop of 10 psi in pressure. These tests shall be repeated until the results are satisfactory to CONTRACTOR, generally at least two times. These procedures shall apply to each 5-foot lift tested. If the expanders are not adequately sealed against the rock, or are in an area of broken rock, the leakage may be observed at the surface by the return of water or detected by other means, in this case the pressure test apparatus should be lowered one foot, and the test repeated. DRILLING SUBCONTRACTOR shall take every precaution to make certain that continuous and reliable pressure tests are completed as specified. If, in the opinion of CONTRACTOR, either the condition of the testing equipment or its assembly and arrangement are thought to be faulty, DRILLING SUBCONTRACTOR may be required to make a series of check tests at his own expense.

DRILLING SUBCONTRACTOR shall record all information pertinent to each packer test. Separate log sheets shall be submitted for each test. These logs shall indicate the type of pump used, boring number, top and bottom depths below the ground surface of each interval tested, pressure employed in each interval, rate of water injection, time interval over which different pressure ranges were obtained, height of the pressure gauge above the ground surface, and any other observations.

Article 20. <u>SAMPLES AND RECORDS</u>

Each sample shall be labelled to show plainly the number of the boring, the sample number, description, depth below the surface from which the sample came, and the resistance to penetration of the sampler.

During the progress of each boring, DRILLING SUBCONTRACTOR shall keep a continuous and accurate log of the materials encountered and a complete record of the operation of sinking the casing.

Records shall include at least the following data:

- Names of driller and inspector.
- Dates and times of beginning and completion of work.
- Identifying number and location of test boring.
- Ground surface elevation at the boring (approximate from U.S.G.S. Topo map).
- Diameter and description of casing.

- Length of casing extending below ground surface at the completion of the boring.
- Weight, number of blows, and drop of hammer used to drive the casing each successive foot.
- Depth to water surface in borehole.
- Depth to top of each different material penetrated.
- Depth to the bottom of sampler at start of driving for each sample.
- Depth to which the sampler was driven.
- Identifying number of each sample.
- Type of sampler used to obtain sample.
- Weight and drop of hammer used to drive the sampler and number of flows required to drive it each 6 inches of penetration.
- Method used to advance tube sampler and force required to advance the sampler each 12 inches.
- Length of sample obtained.
- Distance from the bottom of the sampler to the lower end of the sample when the sampler is not filled to the bottom, and any other circumstances of obtaining the sample.
- Stratum represented by the sample.
- Loss or gain of drilling water or mud.
- Any sudden dropping of drill roads or other abnormal behavior.

SPECIAL CONDITIONS

Article 21. DECONTAMINATION

All drill rigs and tools shall be steam cleaned prior to mobilization on-site. Decontamination of tools shall be accomplished by DRILLING SUBCONTRACTOR upon completion of each boring in which monitoring wells will be installed unless the rig had contact with contaminated materials in which case decontamination of the rig would be required prior to mobilizing to the next boring location. Sample equipment used down hole shall be decontaminated before and after a sample is obtained from a boring. Decontamination of drill tools (casing rods) will be required between installation of each monitoring well in a given nest. The drill rigs, however, will be decontaminated at a minimum at the completion of each monitoring well nests. More frequent decontamination of rig may be required depending on actual exposure to contaminated conditions. All decontamination procedures and methods will be approved by CONTRACTOR prior to their use. It is anticipated that decontamination procedures will take place at each boring location. A central decontamination area may be used if deemed necessary by CONTRACTOR.

In general, decontamination procedures are as follows:

1. All split spoon samplers used shall be decontaminated between each use.

2. All subsurface (downhole) drilling equipment (rods, casing, augers, etc.) must be decontaminated by steam cleaning or other approved method between each borehole.

3. All equipment (including drilling rigs) must be decontaminated by steam cleaning before final departure from the site.

Decontamination procedures for sampling equipment are as follows:

- clean in detergent (TSP) with scrub brush;
- It may also be necessary to rinse equipment with isopropyl alcohol and clean (potable) water as directed by CONTRACTOR.

Article 22 **SOIL DESCRIPTION**

Soil shall be described in accordance with the following classifications:

1.	Texture and Consistency	Topsoil, fill including complete description of character and constituents, gravel, sand, silt, clay, organic silt, peat, meadow mat, etc. Designate predominate soil type last, as in sandy, silty clay with little gravel or fibrous organic silt, some sand lenses and evidence of leaves and grass roots.
2.	Consistency	Sand and gravels - loose, medium, compact, very compact. Clays and silts - soft, medium, stiff, hard.
3.	Plasticity	Non-plastic, slightly plastic, plastic, fat, sticky, etc.
4.	Color	Light, dark, black, blue, yellow, red, brown, etc., as in: dark greenish brown organic silt with some sand.
5.	Moisture	Dry, moist, wet, etc.

At the completion of each week's work, a single translucent, reproducible copy of the logs and records of all borings and records of the groundwater level observations shall be delivered to CONTRACTOR.

The purpose of these borings is to provide reliable information regarding the character and elevation of the soil formations. DRILLING SUBCONTRACTOR shall give CONTRACTOR every facility for obtaining his own records and determining every detail of the work as it progresses.

Article 23. **PLAN OF LOCATION AND ELEVATIONS OF BORINGS**

The locations of the borings shall be staked in the field by CONTRACTOR. Any variation in location or elevation from those established by CONTRACTOR shall be noted on the boring log by DRILLING SUBCONTRACTOR.

Article 24. **CLEAN UP**

On completion of the work, DRILLING SUBCONTRACTOR shall remove his rigs, all surplus and unused material and leave the site in clean condition to the satisfaction of CONTRACTOR. DRILLING SUBCONTRACTOR shall follow the procedures specified in Article 12 regarding the cuttings and drilling fluids from each borehole.

Article 25. **DRILLING FLUIDS, SOLVENTS, GLUES AND LUBRICANTS**

During completion of the work, DRILLING SUBCONTRACTOR will not use any drilling fluids other than potable water. No glue or solvent welding of piezometers or monitoring well components will be allowed. DRILLING SUBCONTRACTOR will not employ oil, grease or other petroleum derived lubricants on drill rods, tools and casings. Any material employed as a lubricant will be approved by CONTRACTOR prior to its use.

Article 26. **ACCESS TO BORINGS**

CONTRACTOR will provide DRILLING SUBCONTRACTOR access to the site. DRILLING SUBCONTRACTOR is responsible for all on-site access including all work required to mobilize to each of the designated boring locations.

Article 27. **UTILITY CLEARANCES**

It is the responsibility of DRILLING SUBCONTRACTOR to clear drilling and boring locations for utilities in order that activities proceed in a safe and orderly manner.